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COMET 1920 a (Comas Sola)

A cablegram received from M. G. Lecointe, Director of the Central International Bureau of Astronomical Telegrams, at Brussels, announced the discovery of a comet by Comas Sola. visible in a large telescope. The comet is apparently stellar.

The following positions are given:

	G. M. T.	R. A.	DEC.
Comas Sola	Jan. 13.5011	8^h 06^m $44.^s0$	+22° 23′ 00″
H. C. Wilson	20.6610	7 57 40.5	+21 40 54
Barnard	24.5240	7 52 35.8	+21 15 08

W. AUHAGEN.

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PRELIMINARY NOTE ON AN ANNUAL TERM IN THE RIGHT ASCENSIONS,

By M. L. ZIMMER.

In January, 1913, it was decided to undertake the determination of the positions of Boss' 1059 stars south of +30° declination by strictly fundamental methods, using the new Meridian Circle of 190 mm. aperture. At that time little had been done to test the new installation. My first task, therefore, was to make the necessary investigations for showing its capabilities. A full description of the instrument with the various investigations will be published in the first volume that appears, containing results obtained with it. Suffice it to say here, that the instrument has been thoroughly tested and the results of the various investigations confirm what was already known of REPSOLD's instruments; namely, that they are of a uniform high degree of excellence and capable of doing work of the greatest precision.

Although the instrument had been shown to be capable of doing work of a very refined character, it was realized from the first that it would count for very little unless we could depend upon the clock to maintain a uniform rate for at least twenty-four hours. The two self-winding Riefler clocks were, therefore, placed in the vault made in the brick structure which supports the instrument, and their cases hermetically sealed. The temperature of the vault has been maintained constant by means of a delicate thermostat in conjunction with an electric heater. By taking chronographic comparisons every twelve hours, one clock has been made to check the other. All causes known to produce diurnal variation in the clock rate having been removed, and the instrument having been thoroughly tested, we were now ready to start the program, which was accordingly, done in December 1916.

Observations made previous to this had shown a very interesting phenomenon. Clock corrections obtained in the evening at or near the vernal equinox were uniformly larger by $^{s}.07$ or $^{s}.08$ than those found from the corresponding morning observations. This was universally the case, regardless of which clock was used, and showed no dependence on observers. From comparisons made with the observations taken at the autumnal equinox, it was shown that not more than half this was due to existing periodic errors in Boss' *P. G. C.* as the difference now became 0. This left an unaccounted for difference of $^{s}.04$ between morning and evening observations. As it was believed that no part of this could be attributed to the clock since it had been freed from all suspicion, and as it had been shown that this difference between morning and evening observations was not due to the personality of the observer, nor to the periodic errors in the star list, it became evident that before we could reduce the fundamental observations, now well nigh completed, an independent investigation of this phenomenon would have to be undertaken. The preliminary results of the investigation form the subject of this paper.

Two groups of about forty stars each, the mean R. A. of the two groups being 6^{h} and 18^{h} respectively, were selected. Observations were begun in March, 1917, and continued through the three successive equinoxes. It was planned to make at least sixteen observations of each star at any one equinox, distributed equally as to clamp, and symmetrically with respect to sunrise and sunset. This program has been carried out. Perfect symmetry with respect to sunrise and sunset has not been attained, due to the uncertainties of the weather; but they have been symmetrical enough to show that little, if any difference exists between transits made in daylight and those taken in darkness.

The observations have been reduced by strictly fundamental methods. Omitting details, for the sake of brevity, the following results show to what degree of accuracy the instrumental constants have been determined, and give an index as to what degree of confidence the results are entitled.

1. COLLIMATION. The collimation has remained constant for upwards of three years. The only changes that have ever been noted are those that occur when for any reason the objective or eye-piece has been changed. During periods of observing it has been determined at intervals of two weeks. The brute mean of all the determinations, made during these three years, has been taken as the most probable value to be employed. On the supposition that it had been a constant during this time the p. e. of a single determination was found to be $\pm^s.002$ with the largest residual only $^s.008$.

2. LEVEL. The level undergoes but slight changes during the twenty-four hours and for long periods of time it often remains practically a constant. The little table covering the first two weeks of March of this year shows that whatever changes have taken place have been slight.

March 1.3	$^s.14$	March 9.8	$^s.17$	March 11.8	$^s.15$
1.8	.14	10.0	.15	12.0	.13
3.3	.11	10.3	.16	12.3	.13
8.3	.17	10.5	.16	12.5	.16
8.8	.18	10.8	.16	12.8	.15
9.0	.15	11.0	.14	13.0	.13
9.3	.17	11.3	.15	13.3	.16
9.5	.16	11.5	.16		

The so called instantaneous values, however, have been used in all cases.

3. AZIMUTH. The azimuth has been determined from upper and lower culminations of the four following circumpolar stars: ξ *Mensæ*, *L 7088*, χ *Octantis* and σ *Octantis*, corrected for clock rate and small changes of azimuth as indicated from the mire readings. The azimuth like the level undergoes but slight changes from day to day. The mire is such, as pointed out by DR. GLANCY in a paper read before the second Pan-American scientific congress, that the instantaneous azimuth of the instrument can be determined from a set of readings (usually the mean of five) with the same accuracy as from upper and lower culminations of a single circumpolar star.

4. CLOCK CORRECTION AND RATE. The clock correction and rate have in all cases been determined in the following manner. Some ten time stars in each group were selected for determining the clock correction, and in order to make the clock corrections the most homogeneous possible, these same stars have been used throughout the work. Each group furnishes, then, a clock correction independent of the other. Assuming the clock correction obtained from the evening observations to have equal weight with that of the morning group, and that the rate had been constant for the week, equations of the following form were set up and solved. $\rho t+\Delta t_0 = \Delta t$ where ρ = rate and Δt_0 the clock correction for the mean of the dates. The week of March 13-17, taken at random, shows the process

		O	C	O–C	V
March	13.25	−44.649	−44.688	+.039	−.010
	13.75	−44.826	−44.783	−.043	+.006
	14.25	−44.835	−44.879	+.044	−.005
	14.75	−45.012	−44.974	−.038	+.011
	15.25	−45.019	−45.070	+.051	+.002
	15.75	−45.218	−45.165	−.053	−.004
	16.25	−45.199	−45.261	+.062	+.013
	16.75	−45.416	−45.356	−.060	−.011
Mean	15.00	−45.022		.049	−.0078

The conditional equations are:

$$\begin{aligned}
-1.75\rho +\Delta t_0 &= -44.649\\
-1.25\rho +\Delta t_0 &= -44.826\\
-0.75\rho +\Delta t_0 &= -44.835\\
-0.25\rho +\Delta t_0 &= -45.012\\
+0.25\rho +\Delta t_0 &= -45.019\\
+0.75\rho +\Delta t_0 &= -45.218\\
+1.25\rho +\Delta t_0 &= -45.199\\
+1.75\rho +\Delta t_0 &= -45.416
\end{aligned}$$

Solving for 24^h clock rate

$$\rho = -.191$$

Substituting now in the conditional equations clock corrections were computed for each date.

The column headed O–C shows with what fidelity the clock correction found from the group observed in the evening differs systematically from that obtained from the group observed in the morning. During the prosecution of the work, not a single exception to this has ever been noted. The column headed V shows how much the actually observed clock corrections differ from those computed on the hypothesis that the rate had been uniform during that period. Since the average deviation is only $^s.008$ there is not much left to be attributed to irregularities in the rate. If a term depending on the square of the time had been put in, the residuals might have been made still smaller; but in the few cases in which such a term was inserted not much improvement was noted. In one or two cases there were found rather larger residuals than was to be expected. This led to a study of the weather maps in the hope that they could be connected with barometric gradients as pointed out by CONRAD of the U. S. Naval Observatory; but we met with little success. The computed clock corrections have been used in all cases to reduce the observations. The final positions are independent of any system, having been reduced by thoroughly fundamental methods.

They are closely related to Boss' system, however, in that the right ascensions of the time stars were taken from his *P. G. C.* Any right ascensions at all could just as well have been used without changing the final results in the least.

The following table gives the results of the observations made at the last three successive equinoxes.

Star	1900.0 α	1900.0 δ	Mag.	Spec.	μ	Obs. Δ_1	Obs. Δ_2	Z − B
	h m	° ′			″	s	s	s
γ Orionis	5 19.8	+ 6 16	1.6	*B2*	.020	+.055	+.046	−.021
β Leporis	24.0	−20 50	2.7	*G*	94	58	56	−.047
δ Orionis	26.9	− 0 22	2.2	*B*	3	58	19	−.012
α Leporis	28.3	−17 54	2.6	*F*	1	16	12	−.029
ι Orionis	30.5	− 5 59	2.9	*Oe5*	5	51	51	−.005
β Doradûs	32.8	−62 33	3.8	*F*	.16	83	63	+.084
σ Orionis	33.7	− 2 39	3.8	*B*	1	51	34	+.001
ζ Orionis	35.7	− 2 0	1.7	*B*	7	17	38	−.050
γ Leporis	40.3	−22 29	3.7	*F*	.468	62	60	−.046
ζ Leporis	42.4	−14 52	3.6	*A*	18	41	45	−.002
δ Doradûs	44.6	−65 46	4.5	*A*	39	49	39	+.121
β Columbæ	47.4	−35 48	3.0	*K*	.397	37	38	+.002
α Orionis	49.8	+ 7 23	1.0 v	*M*	29	52	46	−.033
η Leporis	51.9	−14 11	3.7	*F*	.138	48	46	−.018
γ Columbæ	54.0	−35 18	4.4	*B3*	4	63	48	+.017
η Columbæ	56.1	−42 49	3.9	*K*	33	31	39	+.005
Br. 880	58.0	−23 16	4.3	*G*	.108	48	44	+.012
ν Orionis	6 1.9	+14 47	4.4	*B*	37	35	35	−.005
δ Pictoris	8.4	−54 57	4.9	*B*	22	27	21	+.099
Br. 920	10.0	− 6 15	4.2	*K*	21	25	28	−.025
χ Columbæ	13.0	−35 6	4.5	*K*	76	15	27	+.020
ζ Can. Maj.	16.5	−30 1	3.0	*B3*	8	30	32	−.051
β Can. Maj.	18.3	−17 54	1.8	B1	7	17	31	−.039
α Carinæ	21.7	−52 38	0.	*F*	18	47	52	+.012
ν Geminorum	23.0	+20 17	4.1	*B*	23	36	29	+.022
λ Can. Maj.	24.5	−32 31	4.5	*B5*	32	35	41	+.053
ξ Can. Maj.	27.7	−23 21	4.4	*B1*	8	27	39	−.041
Br. 972	30.9	−22 53	4.6	*A*	14	29	34	+.012
γ Geminorum	31.9	+16 29	1.8	*A*	65	51	45	−.005
ν Puppis	34.7	−43 6	3.1	*B8*	20	26	13	−.018
S Monocerotis	35.5	+ 9 59	5 ± v	*Oe5*	8	41	43	+.014
ε Geminorum	37.8	+25 14	3.1	*G*	20	26	38	−.011
ξ Geminorum	39.7	+13 0	3.3	*F*	.231	34	43	+.005
Sirius	40.7	−16 35	−2.0	*A*	1.316	63	63	−.097
β Aræ	17 17.0	−55 26	2.7	*K*	37	28	31	+.093
Br. 2198	20.3	−24 5	4.2	*F*	.132	57	41	+.048
σ Ophiuchi	21.6	+ 4 14	4.5	*K*	4	54	55	+.032
α Aræ	24.1	−49 48	2.7	*B3p*	90	56	68	+.056
λ Scorpii	26.8	−37 2	1.5	*B2*	36	36	53	+.039
α Ophiuchi	30.3	+12 38	2.0	*A*	.264	71	69	+.014
ξ Serpentis	31.9	−15 20	3.4	*A*	83	45	42	+.019
χ Scorpii	35.6	−38 59	2.4	*B*	28	42	44	+.027
β Ophiuchi	38.5	+ 4 37	2.7	*K*	.158	51	55	+.023
ι Scorpii	40.6	−40 5	3.0	*F*	4	44	58	+.020
μ Herculis	42.5	+27 48	3.4	*G*	.816	73	70	+.084

Star	1900.0 α	1900.0 δ	Mag.	Spec.	μ	Obs. Δ₁	Obs. Δ₂	Z—B
	h m	° ′			″	s	s	s
L 7449	43.1	−37 1	3.1	*K*	68	35	43	+.036
Pi 245	45.6	−34 46	6.1	*B*	17	13	41	+.112
L 7485	49.5	−44 20	5.0	*K*	28	37	58	+.097
ν *Ophiuchi*	53.5	− 9 46	3.4	*K*	.119	43	58	+.010
Br 2259	55.6	+ 2 56	4.0	*B5p*	14	54	58	+.019
θ *Aræ*	58.8	−50 6	3.8	*B*1	30	46	52	+.026
70 *Ophiuchi*	18 0.4	+ 2 31	4.3	*K*	1.13	68	67	+.024
μ *Sagittarii*	7.8	−21 5	4.0	*B*5	6	39	46	+.001
η *Sagittarii*	10.9	−36 48	3.0	*M*	.217	57	38	+.028
δ *Sagittarii*	14.6	−29 52	2.7	*K*	51	30	31	−.013
η *Serpentis*	16.1	− 2 55	3.3	*K*	.898	38	42	+.031
ε *Sagittarii*	17.5	−34 26	1.7	*A*	.139	19	55	+.027
Br. 2311	19.4	+21 43	4.0	*K*	.324	23	32	+.024
λ *Sagittarii*	21.8	−25 29	2.7	*K*	.197	28	33	−.001
Br. 2313	23.5	−14 38	4.7	*A*	9	17	41	+.012
θ *Coronæ Austr*	26.4	−42 23	4.6	*G*	47	20	29	+.008
Br. 2330	29.8	− 8 19	4.0	*K*	.318	16	31	+.029
ζ *Pavonis*	31.4	−71 31	4.1	*K*	.155	10	38	+.224
Br. 2342	36.8	− 9 10	4.8	*F*	14	28	34	+.008
φ *Sagittarii*	39.4	−27 6	3.2	*B*	48	25	30	+.014
Br. 2351	41.4	+20 27	4.3	*F*	.345	11	21	+.053

Δ_1 Difference between March 1917 and September 1917
Δ_2 Difference between March 1918 and September 1917
Z—B Indicated correction to Boss' *P. G. C.*

For all stars north of the zenith, the mean of the March and September results were taken and subtracted from Boss' *P. G. C.* This indicated systematic corrections to the *P. G. C.* of −ˢ.019 for the 6-hour group and +ˢ.022 for the 18-hour group, values agreeing very closely with what Eichelberger at Washington found for Newcomb, although he used only six stars in each group. (See report of American Astronomical Society, 21st meeting.)

The column headed Δ shows the difference between the March and September results. A cursory glance shows that there is a pronounced systematic difference. This is due to the fact that the stars have transited later in the morning than in the evening. This was exhibited in a somewhat different form above, where clock corrections obtained in the morning were shown to be smaller by about ˢ.04 than those obtained in the evening. This has been confirmed so many times at different equinoxes and by different observers that it appears to be definitively established.

It seems very improbable that this difference is caused by a diurnal variation in the clock rate, since running as they do, under constant temperature and pressure, all known causes that produce diurnal variation in the rate have been removed. To produce such an effect, the clock would have to run perfectly in its imperfections since this difference occurs with such regularity and exactness, and is the same for the two clocks. Furthermore, as will be seen from the above table, this difference is not the same for all stars, which it should be if caused by diurnal variation of the clock rate.

The remarkably close agreement of the results of March, 1917 with those of March of this year, would lead us to expect these to be more nearly equal if they were due to something affecting all stars alike. The average variation of these quantities from their mean is two or three times what we should expect if we consider them from the standpoint of their probable error. The accidental p. e. of a single determination of right ascension, made under good conditions, as determined from about two thousand residuals, is not more than ±.010 sec δ. This gives ±ˢ.004 for the p. e. of each Δ or ±ˢ.005 if computed from the differences between the results of March, 1917, and those of March, 1918. The larger p. e. found from these differences is due, partly to the fact that the observations were made under all sorts of conditions and partly to the fact that they contain some small systematic differences which could not be eliminated as the law of the phenomenon

was not yet sufficiently known. The range of these Δ's is twelve or thirteen times their p. e.

There is little if any dependence on spectral type, proper-motion, or declination; but there does seem to be a slight dependence on R. A., magnitude and galactic latitude.

All attempts to explain this phenomenon on physical, physiological or psychological grounds have failed, except that it is due to parallactic displacement. But such parallaxes as these are inadmissible according to present accepted notions of the apparently well demonstrated relations between stellar proper-motion and solar parallactic motion in conjunction with the accepted *Sun's* linear velocity.

It might be well, here, to call attention to the harmony which exists between these results and that found by CHANDLER from a discussion of the effect of parallax on the Z-term in the latitude variation formula (see *A. J.* 530). He finds that a mean parallax of about 0″.10 for stars of the sixth magnitude would completely remove that term and remarks that if this value of the parallax were reasonable he would recommend this method as a very efficient one for determining stellar parallax.

The results of ADAMS and STROMBERG at Mt. Wilson show that for stars of small proper-motion there is little if any dependence of parallax on proper-motion and that the observed parallaxes of these stars are larger than those computed from KAPTEYN's formula. These cases have been noted merely, to point out that there is considerable evidence tending to show that the mean parallaxes are too small and to call in question the apparently demonstrated relation between proper-motion and distance.

On the hypothesis that, at least, some of this difference in my results was due to the effect of parallax a comparison was made with ADAMS' spectroscopically determined parallaxes for all stars in common. In order to make the comparison ADAMS' parallaxes were taken as standard and my results were corrected for what could in any way be interpreted as systematic errors. The following table shows the agreement to be good in general and especially good for the 6-hour group. The agreement of these results is such as to lead us to conclude that the wide range of difference in the observed Δ's is not fortuitous; but to some extent, at least, due to the effect of parallax.

If this phenomenon is universal, it seems certain

6-HOURS GROUP

	π_A	π_z
β Leporis	″.04	″.06
α Leporis	.03	.03
γ Leporis	.15	.12
η Leporis	.05	.05
Br. 880	.05	.05
ε Geminorum	.01	.01
ξ Geminorum	.03	.09

18-HOURS GROUP

	π_A	π_z
μ Herculis	″.09	″.17
70 *Ophiuchi*	.20	.25
η Serpentis	.05	.09
Br. 2311	.03	.00
λ Sagittarii	.08	.03
Br. 2330	.02	.01
Br. 2351	.07	−.02

that it has been the main cause for introducing the periodic errors in practically all star catalogs, since it would be almost impossible to avoid errors of such form and size if such a phenomenon exists. The consistency with which these same or similar errors enter into practically all catalogs points to some other cause than the diurnal variation of clock rate as commonly believed

As stated above, whatever difference there might be between observations made in daylight and those made in the night has been almost, if not quite, eliminated. The program was so arranged that all the observations made just before the equinox were taken in daylight in the morning and in darkness in the evening. After the equinox the same stars were observed in darkness in the morning, while those in the evening were now taken in full day. As very little if any difference could be detected between day and night it has called in question the validity of the magnitude equation. As is well known, stars observed in full day are about five magnitudes fainter than when observed at night, and for that reason if the theory of magnitude equation were true the stars should transit later in daylight than in darkness; but such is not found to be the case. EICHELBERGER, at Washington, finds that stars actually transit earlier in daylight than in darkness, although the stars are four or five magnitudes fainter. This might be due to defective illumination; but with the improvements that have been made in recent years in the methods of illumination such is not likely to be the case.

At the last two equinoxes two groups of stars, one in 0^h R. A. and the other in 12^h were observed in conjunction with the 6 and 18-hour groups. These two groups, of course, culminated at mid-day and mid-night. Due to the difficulty of observing at mid-day, the obser-

vations are too few to be of much value; but they show beyond doubt that there is no difference in clock corrections obtained at mid-day and those obtained at mid-night. From now on the four groups at intervals of six hours will be observed at the solstices as well as at the equinoxes. It is hoped and expected, that, by the end of the present year when the program has been completed, we will have the data necessary to a complete solution of this important phenomenon, and to the formulating of its law so that observations made here in the future can be freed from its effect.

This opportunity is taken to express appreciation of the continued interest in this investigation of Drs. Perrine and Glancy. They have been ever ready to discuss the various phases of the work and have made many valuable suggestions. Dr. Perrine has left no stone unturned to make the installation the best possible, and that fact has contributed more than anything else to the detection of this phenomenon.

The following is a resumé of the results of the preliminary investigation.

1. There is something other than the instrument, clock, personal equation, or difference between observing in daylight and darkness that causes the stars to transit later in the morning than in the evening.

2. This difference is not the same for all the stars; but individual stars give different values.

3. That this difference is due to parallactic displacement would seem to be the logical conclusion were it not for the fact that present notions exclude parallaxes of any such size.

4. That some part of this difference is due to parallax seems certain.

5. It seems probable that this phenomenon has been an important factor in introducing the periodic errors in practically all star catalogs.

6. That the Z-term in the latitude variation formula may be caused by parallactic displacement, as pointed out by Chandler in *A. J.* 530, is in harmony with the results of this investigation.

7. Stromberg's conclusion that for stars of small proper-motion the parallaxes are independent of proper-motion is also in harmony with these results.

8. While the evidence of this investigation points strongly to parallax as the main factor in producing this phenomenon, in view of all the facts it seems the part of wisdom to await the extension of data, particularly to other regions of sky, now in progress at this observatory, before attempting an explanation.

Observatorio Nacional Argentino, Cordoba, June, 1918.

THE VARIABILITY OF *NOVA CYGNI* OF 1876

By E. E. Barnard

In *Monthly Notices, R. A. S.*, Vols. LXIII, March 1902, and LXXII, April 1912, my observations showed this star to be variable. There was, however, some uncertainty as to whether this variability was not in the comparison star *No. 51* which had been used throughout the work. Further special observations distributed over the past two years verify the variability of the *Nova* (which amounts to nearly a whole magnitude) and show that the light of star *51* is constant. The observations are being continued to see if the period is constant.

Yerkes Observatory, Williams Bay, Wisconsin, December 9, 1918.

NEW DOUBLE STARS.

By E. D. Roe, Jr.

The following twenty-four pairs of stars have been confirmed as new and their positions verified or corrected by Professor Eric Doolittle. I am under much obligation to him for this as well as for the loan of Jonckheere's *Catalogue of New Double Stars.* Eleven of the pairs were discovered with my $6\frac{1}{2}$-in. refractor and thirteen with the 24-in. refractor of the Sproul Observatory. These thirteen were among twenty-five altogether found with the 24-in. Some of them I did not even suspect of being new. The work on the twenty-five pairs with the 24-in. was done on nineteen nights and would not, I think, average three hours a night. Most of the time had to be spent in measuring position angles and distances and $\Delta\alpha$'s and $\Delta\delta$'s with respect to neighboring bright stars in order to identify all the pairs in some star catalogue or determine their positions. The weather failed to fulfill expectations warranted by weather graphs of several previous years.

There was considerable cloudy weather and it was scarcely ever possible to use any but the lowest power on the 24-in. Position angles and distances may not be very reliable. In the statements of positions it is not intended to guarantee $\Delta\alpha$ and $\Delta\delta$ to tenths of a second of time and thousandths of a minute of arc, but merely to record the readings as observed. I believe

the positions are correct to the nearest second of time and minute of arc.

For the privilege of using the 24-in. for this work I am again under great obligation to Dr. J. A. Miller, Director of the Sproul Observatory. I am also under obligation to Mrs. Roe for going over the calculations for positions.

All the positions have been verified with the 6½-in.

ρ 115, *B.D.* −4° 18′
0h 10m 4s, −4° 39′ (1880)
0h 12m 7s, −4° 26′ (1920)
(9.9, 10.4) (8-11-17; 6½-in.)

	°	″
1917.854	301.7	5.62
.857	.9	.45
.860	.5	.40
1917.857	301.7	5.49

ρ 116, *B.D.* +26° 35′
0h 14m 37s, +26° 58′ (1880)
0h 16m 42s, +27° 11′ (1920)
(9.6, 10.1) (15-10-17; 6½-in.)

28s.8 preceding and 6′.39 south of *A.G. Camb.* (Eng.) 157 which was used in determining the position.

1917.789	263.0	5.09
.792	262.4	.46
1917.791	262.7	5.28

ρ 117, 0h 34m 12s, +12° 46′ (1880)
0h 36m 16s, +12° 59′ (1920)

33s.3 preceding and 5′.36 south of *A.G. Leip.* I. 169.
(10.8, 11.2) (9-10-18; 24-in.)

1918.773	127.3	3.00

ρ 118, *B.D.* +8° 3245
16h 32m 31s, +8° 7′ (1880)
16h 34m 27s, +8° 2′ (1920)

15s.5 following and 1′.77 north of *A.G. Leip.* II. 7424 which was used for determining the position.
(10.2, 10.2) (15-7-18; 6½-in.)

1918.536	34.5	6.50
.542	.6	6.44
.548	.5	5.83
1918.542	34.5	6.26

ρ 119, 17h 37m 0s, +28° 34′ (1880)
17h 38m 34s, +28° 33′ (1920)

43s.4 preceding and 1′.07 south of *B.D.* +28° 2808. Six nearby stars. (27-6-18; 6½-in.)

	°	″
1918.488	321.0	4.72
.501	319.1	.73
.504	319.9	.13
1918.498	320.1	4.53

ρ 120, 17h 51m 51s, +15° 32′ (1880)
17h 53m 39s, +15° 32′ (1920)

46s.3 preceding and 6′.79 north of *A.G. Berlin* A. 6523.
(10.5, 10.7) (11-7-18; 6½-in.)

1918.525	240.0	5.17
.531	.7	.31
.536	.3	.40
1918.531	240.3	5.29

ρ 121, *B.D.* +10° 3434
18h 7m 33s, +10° 51′ (1880)
18h 9m 26s, +10° 52′ (1920)

27s.3 preceding and 3′.77 north of *A.G. Leip.* I. 6487 which was used in determining the position.
(9.6, 10.1, 11) (17-7-18; 6½-in.)

AB	1918.542	60.7	4.37
	.548	58.9	.74
	.594	58.5	.40
	1918.561	59.1	4.50
AC	1918.542	20.2	38.86
	.548	.0	.98
	1918.545	20.1	38.92

ρ 122, 18h 9m 29s, +15° 14′ (1880)
18h 11m 18s, +15° 14′ (1920)

59s.1 preceding and 4′.85 south of *A.G. Berlin* A. 6688.
(9.5, 9.9) (26-7-18; 6½-in.)

1918.567	268.0	6.39
.594	267.8	6.01
.597	268.8	5.80
1918.586	268.2	6.07

ρ 123, *B.D.* +8° 3667
18h 17m 7s, +8° 31′ (1880)
18h 19m 2s, +8° 32′ (1920)

13s.4 following and 0′.95 south of *A.G. Leip.* II. 8447 which was used in determining the position.
(9.8, 10, 12) (7-8-18; 6½-in.)

		°	″
AB	1918.600	222.4	4.67
	.606	221.6	5.38
	.619	221.1	5.29
	1918.608	221.7	5.11
AC	1918.600	234.0	27.00
	.606	231.5	.05
	.619	232.1	.22
	1918.608	232.5	27.09

ρ 124, 18h 56m 10s, +16° 20′ (1880)
18h 57m 58s, +16° 23′ (1920)

3s.4 following and 6′.797 north of *A.G. Berlin* A. 7170.
(9.7, 9.9) (6-8-18; 6½-in.)

1918.597	232.8	6.31
.600	232.6	5.92
.606	233.0	5.42
1918.601	232.8	5.88

ρ 125, *B.D.* +14° 3793
19h 2m 41s, +14° 36′ (1880)
19h 4m 34s, +14° 41′ (1920)

49s.9 preceding and 2′.23 north of *A.G. Leip.* I. 7065 which was used in determining the position.
(6-8-18; 6½-in.)

AB	1918.606	263.1	7.40
	.619	261.2	.99
	1918.612	262.2	7.70
AC	1918.606	36.3	39.45
	.619	35.9	40.08
	1918.612	36.1	39.77

ρ 126, 20h 49m 17s, +16° 14′ (1880)
20h 51m 8s, +16° 23′ (1920)

Estimated position.
(10.4, 10.5) (31-7-18; 6½-in.)

1918.580	150.0	6.82
.606	149.8	.82
.619	150.0	.49
1918.602	149.9	6.71

Measures scarcely more than estimates with the micrometer.

ρ 127, *B.D.* +13° 4742
21h 29m 37s, +13° 10′ (1880)
21h 31m 32s, +13° 21′ (1920)

These positions were obtained by using the *B.D.* differences.

B.D. 4741 − 4742 $\Delta\alpha = +6^s.9$,
$\Delta\delta = -41'.2$

and 4741 as *A.G. Leip.* I. 8572.

But by reducing *B.D.* 4742 from 1855 as given in the *B.D.*, we get
21h 29m 36s, +13° 11′ (1880)
21h 31m 31s, +13° 22′ (1920)
(10.1, 10.4) (27-9-18; 24-in.)

1918.770	25.3	0.62
.773	.9	.63
1918.772	25.6	0.63

I had previously made the following measures which I think should be thrown out.

1918.740	31.0	0.90
.754	32.8	.77

ρ 128, 21h 33m 20s, +12° 20′ (1880)
21h 35m 16s, +12° 31′ (1920)

56s.6 preceding and 7′.4 south of *A.G. Leip.* I. 8620.
(10.5, 10.8) (27-9-18; 24-in.)

1918.740	268.2	1.14
.772	265.3	.26
1918.756	266.8	1.20

ρ 129, *A.G. Berlin* B. 8618
22h 17m 41s, +22° 23′ (1880)
22h 19m 34s, +22° 35′ (1920)
(9, 10.3, 10.7) (13-10-18; 24-in.)

AB	1918.783	209.3	89.42
	.833	.3	87.72 (6½-in.)
	1918.808	209.3	88.57

B is 2s.8 preceding and 1′.32 south of *A* and has the position
22h 17m 38s, +22° 22′ (1880)
22h 19m 32s, +22° 34′ (1920)

		°	″	
BC	1918.783	298.2	5.01	
	.786	.8	4.43	
	.849	.6		(6½-in.)
	1918.806	298.5	4.72	

Other faint stars near, one at 238° 53′ from *A*.

ρ 130, 22h 30m 53s, +10° 53′ (1880)
22h 32m 52s, +11° 5′ (1920)

4s.4 preceding and 5′.83 north of *A.G. Leip.* I. 9027.
(11, 11.1) (19-10-18; 24-in.)

1918.799	293.1	0.64
.805	292.9	.61
.808	291.9	.52
1918.804	292.6	0.59

ρ 131, 22h 45m 0s, +10° 40′ (1880)
22h 46m 59s, +10° 53′ (1920)

13s.6 following and 7′.27 south of *A.G. Leip.* I. 9114.
(10.4, 10.6) (23-9-18; 24-in.)

1918.729	253.2	2.09
.767	250.3	1.89
.770	250.1	1.94
1918.755	251.2	1.97

ρ 132, 22h 57m 15s, +10° 50′ (1880)
22h 59m 16s, +11° 3′ (1920)

5s.1 following and 7′.569 north of *A.G. Leip.* I. 9193.
(10, 10.6) (3-10-18; 24-in.)

1918.756	57.8	1.78

ρ 133, *B.D.* +10° 4896
23h 5m 20s, +11° 5′ (1880)
23h 7m 21s, +11° 18′ (1920)
(9.6, 10.3) (23-10-18; 24-in.)

1918.810	324.4	1.87

ρ 134, *B.D.* +16° 4886
23h 6m 1s, +16° 42′ (1880)
23h 8m 0s, +16° 54′ (1920)
(10.2, 10.4) (14-10-18; 24-in.)

1918.786	65.4	4.18

A faint star north.

ρ 135, *B.D.* +11° 4988
23h 15m 47s, +11° 12′ (1880)
23h 17m 48s, +11° 25′ (1920)
(10.1, 11.6) (16-10-18; 24-in.)

1918.792	136.3	0.51
.797	134.0	.64
1918.795	135.2	0.58

A faint star north.

ρ 136, 23h 21m 50s, +9° 38′ (1880)
23h 23m 51s, +9° 52′ (1920)

34s.0 following and 0.92′ north of *B.D.* +9° 5218.
(10.4, 10.5) (3-10-18; 24-in.)

1918.767	269.1	6.28

ρ 137, 23h 21m 52s, +9° 45′ (1880)
23h 23m 53s, +9° 58′ (1920)

1s.8 following and 6′.48 north of ρ 136.
(10.3, 10.5) (3-10-18; 24-in.)

1918.767	62.1	7.82

My interest in observing these two pairs with the 24-in. was in their both being in the same telescope field.

ρ 138, 23h 23m 23s, +10° 28′ (1880)
23h 25m 24s, +10° 41′ (1920)

3s.1 following and 12′.87 north of *A. G. Leip.* I. 9329.
(10.5, 10.6) (7-10-18; 24-in.)

1918.767	270.0	2. (estimated)
.770	275.2	3.64

Roe Observatory, 16 November, 1918.

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A STUDY OF THE MOTIONS IN Σ 208, 10 *ARIETIS*, AND IN Σ 1834.

By ERIC DOOLITTLE.

Each of these pairs has been known for nearly a century and on each of them a large number of measures has accumulated, yet from a mere inspection of the observations it cannot be told in either case whether the motion is orbital or whether we have here a case merely of proper-motion. The two systems are very much alike in that when first discovered the pairs were quite wide, but since discovery the companion has been moving almost in the direction of the principal star so that each pair is now a very close one. This makes the investigation of the apparent path very difficult by the usual methods, since a large motion changes the position angle but little. In each case the preliminary position of the path was found by a least-square adjustment based upon the distances alone; this was then improved by using both position angles and distances, and the final elements were determined by using the position angles only. In each case [*vv*] was found to have its smallest value when based on the measured angles alone, even though the motion is so peculiar as in these two systems.

Burnham says of each of these pairs that the motion is well represented upon the hypothesis of rectilinear motion. Lewis states that they are both binary, reaching this conclusion with the first pair because the motion of the companion is nearly at right angles to the proper-motion as determined by meridian circle observations, and with the second because there is increase of velocity along the path since the time of the first measure. If the pairs are binary, each orbit must be turned nearly edgewise toward us and the motion in angle during the next few years may be expected to become very rapid. Indeed an almost complete reversal of the direction of motion of the companion may be expected. Observations of these two pairs are therefore of especial importance at this time.

Σ 208. 10 *Arietis*. 6.2 8.0

R. A. = $1^h\ 56^m\ 50^s$; Decl. = 25° 21′.

The individual observations (corrected for precession to the epoch 1880.0) are shown in the first three columns of the following table.

Date	θ	ρ	Δθ	Δρ	Observer
	°	″	°	″	
1821.39	23.6	2.00	− 0.5	−0.46	Σ 1*n*
1831.79	25.9	2.06	− 0.1	−0.49	*H* 4*n*
1833.05	25.3	1.98	− 0.7	−0.17	Σ 4*n*
1833.36	27.9	2.02	+ 1.8	−0.15	Dawes
1838.66	26.9	2.2:	0.0	+0.12	Smyth
1842.10	26.9	1.97	− 1.1	+0.02	Glaisher 2*n*
1842.77	30.3	1.60	+ 2.1	−0.33	Maed. 12*n*
1843.69	30.0	1.69	+ 1.6	−0.22	Maed. 4*n*
1851.35	32.9	1.53	+ 1.7	−0.20	Maed. 3*n*
1851.76	29.7	1.60	− 0.9	−0.12	OΣ 1*n*
1853.92	30.8	1.84	− 0.6	+0.18	Dawes 2*n*
1856.21	31.7	1.60	− 0.6	0.00	Maed. 4*n*
1856.70	34.3	1.65	+ 1.9	+0.06	Secchi 4*n*

Date	θ	ρ	Δθ	Δρ	Observer
	°	″	°	″	
1856.72	34.1	1.30	+ 1.6	−0.29	Δ 3*n*
1862.94	36.1	1.28	+ 1.0	−0.18	Maed. 2*n*
1863.07	34.0	1.43	+ 1.1	−0.02	Δ 6*n*
1866.06	38.1	1.51	+ 1.6	+0.13	Secchi 1*n*
1868.00	39.7	1.34	+ 2.4	+0.01	Δ 3*n*
1871.45	39.0	1.41	− 0.6	+0.17	Duner 5*n*
1873.93	40.1	1.32	+ 1.2	+0.12	Wil. and Sea. 3*n*
1874.28	44.0	1.32	− 2.7	+0.13	Δ 3*n*
1878.05	46.1	1.23	+ 2.3	+0.13	Hall 2*n*
1878.42*	47.9	1.13	+ 3.8	0.00	Schiap. 3*n*
1883.14	50.9	1.48	+ 2.8	+0.49	Engel. 6*n*
1883.86	50.4	1.05	+ 2.6	+0.07	Perrotin 2*n*
1888.05	49.2	0.93	− 3.9	+0.03	Schiap. 4*n*
1888.19	54.9	1.08	+ 1.6	+0.18	HΣ 6*n*
1888.97	53.9	1.13	− 1.0	+0.23	Hall 3*n*
1889.03	52.4	0.88	− 2.0	0.00	Schiap. 6*n*
1890.32	61.0	1.30	+ 5.1	+0.45	Niesten 4*n*
1892.06	55.6	0.94	− 2.5	+0.11	Schiap. 12*n*
1895.18	62.5	0.92	− 1.6	+0.14	HΣ 2*n*
1896.95	61.3	0.93	− 4.1	+0.17	Lewis 2*n*
1898.29	62.7	0.80	− 5.0	+0.06	Bowyer 3*n*
1898.98	62.3	0.60	− 6.6	−0.14	Bryant 2*n*
1899.23	62.4	0.78	− 6.9	+0.06	Aitken 3*n*
1900.24	69.1	0.78	− 2.0	+0.07	Aitken 3*n*
1901.64	67.2	0.65	− 6.7	+0.04	Bowyer 4*n*
1903.98	73.0	0.70	− 5.4	+0.03	Bowyer 2*n*
1904.10	78.9	0.71	− 0.2	+0.04	Furner 1*n*
1904.53	87.4	0.55	+ 7.6	−0.12	Bowyer 2*n*
1905.56	77.2	0.49	− 4.5	−0.16	Aitken 3*n*
1907.05	91.1	0.48	+ 6.0	−0.16	Bowyer 1*n*
1907.16	78.5	0.58	− 7.9	−0.06	Furner 1*n*
1907.60	73.7	0.48	−12.6	−0.16	Lau 1*n*
1908.68	94.7	0.40	+ 1.2	−0.24	Bies. 7*n*
1910.08	101.5	0.26	+ 9.4	−0.37	Bowyer 2*n*
1911.08	96.0	0.38	− 1.6	−0.25	Bryant 1*n*
1911.26	92.0	0.40	− 2.9	−0.23	Aitken 3*n*
1911.49	98.0	9.29	− 2.6	−0.34	Bowyer 2*n*
1912.37	95.3	0.5:	− 2.2	−.13	Doberck 3-1*n*

* Called 1878.12 by Lewis.

From these there are formed the following eight normal places:—

Date	θ	ρ	
	°	″	
1831.718	24.74	1.98	Σ 5*n*
1855.480	32.98	1.38	Σ 1*n*, (Wt. 1); Δ 3*n*, (Wt. 3).
1864.713	35.88	1.40	Δ 6*n*, (Wt. 2); Δ 3*n*, (Wt. 1)
1875.537	44.72	1.29	Δ 3*n*, (Wt. 2); Hall 2*n*, (Wt. 1)

Date	θ	ρ	
	°	″	
1888.560	52.57	1.04	Sch. 4n, H Σ 6n, Hall 3n, Schi. 6n, (Each Wt. 1)
1896.597	64.18	0.85	Nies. 4n, A. 3n, A. 3n, (each Wt. 1, except Niest. dist., Wt. ½
1904.972	76.82	0.56	[Bow. 4n, (Wt. 4); Bow. 2n, Wt. 2; Fur. 1n, Wt. 1]; [Bow. 2n, Bow. 1n, Fur. 1n, Lau. 1n]; Ait. 3n., (each Wt. 1)
1909.970	93.36	0.40	Bies. 7n, Aitken 3n; (Wt. 1 each)

After three successive adjustments the following elements were found, the corresponding residuals being given in Columns 4 and 5 of the above Table.

$$\alpha = 189^\circ.27$$
$$p = 0''.626$$
$$T = 1913.123$$
$$\mu = 0''.025963$$

A very slight inspection of Column 5 of the above Table renders it very evident that there is a decided curvature of the path, and when the velocities along the path are determined they show a steady and progressive increase, the average velocity prior to 1875 being 0″.0171 and since that time 0″.0233, the linear velocity in 1911 being no less than 0″.032.

We may therefore conclude that the pair Σ 208 is certainly a binary.

Σ 1834. 7.1 7.2 R. A. = $14^h\ 15^m\ 54^s$; Decl. = 49° 3′

The various observations (corrected for precession) are shown in the following Table.

Date	θ	ρ	Δθ	Δρ	Observer
	°	″	°	″	
1829.73	113.2	1.36	+ 1.8	−0.41	Σ 2n
1831.09	107.0	1.16	− 4.5	−0.58	h 4n
1832.66	113.7	1.37	+ 2.1	−0.34	Σ 2n
1840.54	111.6	1.13	− 0.1	−0.37	Dawes 2n
1841.53	112.8	1.21	+ 1.0	−0.26	OΣ 2n
1843.23	113.7	1.37	+ 1.9	−0.06	Maed. 3n
1848.86	111.9	1.07	− 0.3	−0.21	Dawes 2n
1851.51	113.2	1.00	+ 1.0	−0.21	OΣ 1n
1857.57	114.7	0.92	+ 2.2	−0.13	Secchi 2n
1864.49	100.8	0.87	−12.3	−0.00	Barclay 1n
1866.31	103.2	0.86*	− 0.1	+0.04	Δ 3n–2n
1866.49	110.8	0.87	− 2.5	+0.06	Talmage
1871.21	115.4	0.66	+ 2.4	−0.03	Duner 4n
1871.53	115.2	0.6:	+ 2.2	−0.1:	Gledhill 1n
1874.01	116.0	0.80	+ 1.6	+0.18	OΣ 2n
1874.42	113.7	0.6:	− 0.8	0.0:	Wilson 1n
1879.47	114.8	0.46	− 1.0	−0.01	Hall 3n
1881.54	124.5	0.55	+ 7.8	+0.13	Seabroke 3n
1883.61	117.4	0.51	− 0.2	+0.14	Engel. 6n
1885.53	118.6	0.42	− 0.3	+0.09	Hall 3n
1892.17	125.2	0.26	− 4.1	+0.09	β 2n
1893.47	145.6	0.39	+ 9.3	+0.28	Lewis 1n
1893.58	293.7	0.25	−23.0	+0.14	Comstock 1n
1895.53	Single.		.....	.....	Comstock 2n
1897.51	166.6		−13.5	.....	Lewis 1n
1897.63	Round.		.....	.....	Bryant 1n
1899.40	270:	0.20 }	+13:	...	Brown 1n
1899.45	200:	... }			Bryant 1n
1900.49	209.3	0.22	−49.0	+0.13	Bryant 1n
1900.54	206.9	0.25	−47.3	+0.25	Bowyer 1n

Date	θ	ρ	Δθ	Δρ	Observer
	°	″	°	″	
1901.16	202.1	0.23	−59.5	+0.22	Lewis 1*n*
1901.31	219.5	0.18	−45.2	+0.07	Bryant 3*n*
1902.73	118.3	0.28	+ 6.9	+0.14	Bryant 1*n*
1903.60	96.5	0.12	+ 3.5	−0.05	Aitken 1*n*
1904.33	5:		+88:		Bies. 2–0*n*
1904.34	Round with 36-inch		. .		Hussey 1*n*
1906.43	182.4	0.14	−84.5	−0.10	Bryant 1*n*
1906.61	No elongation.		. . .	. . .	Aitken 1*n*
1907.32	343.4	0.14	+54.6	−0.12	Bryant 2*n*
1907.12	Single in 15-inch.		. . .		Bies. 8*n*
1908.44	213.8	0.32	−66.2	+0.02	Doberck 2*n*
1908.58	359.1	0.13	+79.1	−0.16	Bryant 1*n*
1909.68	106.8	0.12	+ 5.5	−0.19	Bryant 3*n*
1910.28	98.7	0.22	− 2.9	−0.17	Bryant 2*n*
1911.43	102.4	0.16	+ 0.3	−0.20	Bryant 3*n*
1911.49	61.3	0.19	−40.8	−0.18	Bowyer 2*n*
1911.49	84.0	0.17	−18.1	−0.20	Aitken 2*n*
1912.46	91.3	0.16	−11.3	−0.23	Bryant 3*n*

An estimated distance of 1″.00 is here included by Lewis.

In attempting to form normal places from these, it is seen that the observations since 1901 appear hopelessly inconsistent and this uncertainty is increased by the circumstance that the stars are of so nearly equal brightness that the quadrant is in all cases uncertain. Even if we assume that the companion passed around the principal star about 1900 (as seems probable), and that the motion has become reversed, about 4-10ths of the later observations are wholly inconsistent with the others. As this investigation is only to ascertain whether it is possible to represent the motion by a straight line, however, it is here assumed that the companion has remained in the third and fourth quadrants, and the following places, reasonably consistent with the hypothesis, are made the basis of the computation.

Date	θ	ρ	
	°	″	
1831.195	113.45	1.36	Σ 4*n*
1844.365	112.30	1.12	(Da. 3*n*, Wt. 3; Da. 2*n*. Wt. 2) Wt. 1; (OΣ 2*n*, Wt. 2; OΣ 1*n*, Wt. 1) Wt. 1
1866.310	113.22	0.86	Δ 3–2*n*
1874.897	115.40	0.64	Da. 4*n*, Wt. 1; OΣ 2*n*, Wt. 1; Hall 3*n*, Wt. 1
1884.570	118.03	0.46	Eng. 6*n*, Wt. 1; Hall 3*n*, Wt. 1
1892.170	125.17	0.26	β 2*n*
1903.600	276.45	0.12	Aitken 1*n*
1911.068	276.63	0.19	Bry. 3*n*; Bry. 2*n*; Bry. 3*n*; A. 2*n*; Bry. 3*n*; Wt. 1 each

The third least-square adjustment leads to the following elements, the corresponding residuals being given in Columns 4 and 5 of the above table. An inspection of the fifth column renders it evident that, as in the preceding case, the motion is orbital; the velocity in the path has also more than doubled since the time of the first measure.

$$\alpha = 289^\circ.87$$
$$p = 0''.049$$
$$T = 1897.471$$
$$\mu = 0''.02631$$

Although it seems certain that each of these pairs is thus a true binary system, a very brief ephemeris of

each is computed on the hypothesis of rectilinear motion. Observations of these pairs are now of special importance. It is to be expected that the positions obtained will be very different from those of the following table.

	Σ 208		Σ 1834	
	θ	ρ	θ	ρ
1918.0	110°.70	0″.64	284°.69	0″.54
1920.0	115 .10	0 .65	285 .53	0 .65
1922.0	119 .18	0 .67	286 .11	0 .75

The Flower Observatory, June 12, 1918.

OBSERVATIONS OF WOLF'S ASTEROID, 1918 *DB*,

MADE WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY,

By G. VAN BIESBROECK.

Date	Gr. M.T.	Δα	Δδ	No. of Comp.	App. α	App. δ	log pΔ		*
1918	h m s	m s	′ ″		h m s	° ′ ″			
Feb. 12	19 37 19	−1 5.74	+9 11.4	12, 6	7 21 9.45	+36 5 59.8	9.657	0.441	1
16	19 58 51	−3 58.65	−2 51.7	6, 6	34 11.77	36 38.5	9.684	.486	2
17	14 4 13	−1 33.12	+1 9.6	20, 6	36 37.30	40 39.9	9.348*n*	.086	3
19	19 34 18	+0 29.86	−1 41.7	6, 6	43 35.63	49 6.9	9.664	.433	4
20	17 7 16	+3 17.67	+0 32.5	16, 6	46 23.43	51 21.0	9.306	.052	5
23	19 14 4	−3 53.51	−3 3.8	12, 4	7 55 46.56	53 38.7	9.643	.392	6
Mar. 2	18 25 25	−0 13.92	−0 25.8	6, 6	8 15 51.13	36 31 13.3	9.574	.296	7
16	18 46 34	+0 19.54	+3 15.1	6, 6	8 51 55.25	34 40 15.2	9.630	.433	8
17	13 33 27	+2 12.48	−5 10.5	6, 6	8 53 48.18	34 31 49.7	9.327*n*	.180	9
26	19 16 30	+0 14.76	−2 21.7	6, 6	9 14 51.09	32 41 5.1	9.671	.550	10
27	17 24 8	+0 1.43	−7 32.2	6, 6	16 52.25	32 29 10.6	9.500	.352	11
Apr. 7	16 14 48	−0 57.39	+1 24.4	12, 6	39 39.67	29 58 47.3	9.338	.345	12
9	19 3 6	−0 35.86	−3 24.8	20, 6	43 52.20	29 28 22.7	9.666	.603	13
10	16 41 0	+0 7.82	−1 4.5	6, 6	45 38.51	29 15 18.5	9.442	.404	14
13	18 41 23	+0 13.17	+0 56.4	6, 6	9 51 38.42	28 30 17.4	9.651	.593	15
May 7	17 57 16	+0 19.20	−5 56.5	4, 4	10 35 15.55	+22 31 18.7	9.635	.654	16

Comparison Stars.

*	α 1918.0	δ 1918.0	Red. to App. Pl.		Authority
	h m s	° ′ ″	s	″	
1	7 22 11.88	35 56 51.3	+3.31	− 2.8	Lu. 3848
2	7 38 7.07	36 39 33.9	+3.35	− 3.7	Lu. 3960
3	7 38 7.07	36 39 33.9	+3.35	− 3.6	Lu. 3960
4	7 43 2.42	36 50 52.1	+3.35	− 3.7	Lu. 3985
5	7 43 2.42	36 50 52.1	+3.34	− 3.6	Lu. 3985
6	7 59 36.70	36 56 47.2	+3.37	− 4.7	Lu. 4090
7	8 16 1.72	36 34 44.4	+3.33	− 5.3	Lu. 4204
8	8 51 32.50	34 37 7.0	+3.21	− 6.9	Kü. 3948
9	8 51 32.50	34 37 7.0	+3.20	− 6.8	Kü. 3948
10	9 14 33.23	32 43 34.7	+3.10	− 7.9	Pots. ph. IV, p. 253, No. 132; VI, p. 94, No. 72.
11	9 16 42.96	32 36 50.8	+3.09	− 8.0	Pots. ph. IV, p. 255, No. 28; VI, p. 94, No. 107.
12	9 40 34.11	29 57 31.9	+2.95	− 9.0	Kü. 4311.
13	9 44 25.13	29 31 56.6	+2.93	− 9.1	Oxf. ph. 30° 23860; 29° 28036.
14	9 45 27.78	29 16 32.1	+2.91	− 9.1	Oxf. ph. 30° 23840; 29° 28007; 29° 28349.
15	9 51 22.37	28 29 30.4	+2.88	− 9.4	Oxf. ph. 29° 28230; 28° 29907.
16	10 34 56.35	22 37 26.0	+2.64	−10.8	*B.D.* 22° 2252 (5 obs. Abbadia).

REMARKS.

March 2. Estimated $13^{M}.5$

March 26. Very difficult on account of moonlight.

May 7. Estimated $15^{M}.5$. Very difficult. Hazy sky. Cloudy weather and moonlight brought the series to an end before the object had reached the limit of the instrument. The position of Star 4, as given by me in *Harv. Bull.* 654 requires a correction of 9″.6 in declination (See *Bull. Lick Observatory*, No. 309).

Yerkes Observatory, July 10, 1918.

THE MOTION OF WOLF'S COMET IN 1918 AND 1919,

BY M. KAMENSKY.

For the investigation of the motion of WOLF'S Comet in 1918, it was necessary to make further calculations of the perturbations of the elements of its orbit. This work was made by me according to the formulas and methods put down already in my "Recherches sur le mouvement de la Comete WOLF." Taking as basis the calculations the system of elements K'_9, published by me in *A. J.* 738, I calculated the exact values of the perturbations in the motion of the Comet during the period Jan. 10, 1918 to Dec. 16, 1918; the perturbations of second order for the said period being equal to zero.

Perturb.	*Earth + Moon*	*Mars*	*Jupiter*	*Saturn*	*Sum*
	″	″	″	″	″
δM	+0.50	+0.07	−21.88	+0.14	−21.17
$\delta \varphi$	+3.75	+0.24	−37.69	−1.57	−35.27
$\delta ☊$	−0.33	−0.02	−26.53	−2.26	−29.14
$\delta \pi$	−2.54	−0.35	+64.19	−3.61	+57.69
δi	−0.22	−0.02	− 1.23	−0.05	−1.52
δn	−0.03529	−0.00238	+ 0.32482	+0.00185	+0.28900

Adding these perturbations to the system K'_9, I get the following system K'_{10}, from which the Ephemeris for 1919 has been calculated.

DECEMBER 16.0, 1918, B. M. T.

$$K'_{10}\quad \begin{array}{rl} M = & 0°\ 22'\ 2''.50 \\ \varphi = & 33\ 57\ 56.58 \\ ☊ = & 206\ 34\ 16.20 \\ \pi = & 19\ 30\ 29.61 \\ i = & 25\ 17\ 33.22 \\ ☊ = & 206\ 41\ 53.36 \\ \pi = & 19\ 38\ \ 1.44 \\ i = & 25\ 17\ 29.65 \\ n = & 522''.71793 \end{array} \begin{array}{l} \\ \\ \left.\begin{array}{l}\\ \\ \\ \end{array}\right\}\ 1910.0 \\ \left.\begin{array}{l}\\ \\ \\ \end{array}\right\}\ 1919.0 \\ \\ \end{array}$$

The equatorial rectangular heliocentric coördinates for the mean equinox 1919.0 are calculated by the formulas:

$$x = r\,[9.991848]\sin(107°\ 23'\ 12''.9 + f)$$
$$y = r\,[9.999981]\sin(\ 17\ \ 16\ \ 43\ .6 + f)$$
$$z = r\,[9.283732]\sin(104\ \ 27\ \ 18\ .5 + f)$$

As will be seen from the Ephemeris, the position of the Comet is getting more unfavorable to observe every day, as it is getting nearer to the *Sun*. This is very evident from the following table:

	α comet	$\alpha_\odot$	δ comet	$\delta_\odot$
	h m	h m	°	°
1919 Jan. 5	23 53	19 1	−3.9	−22.7
Jan. 21	0 38	20 10	−3.0	−20.1
Feb. 6	1 21	21 16	−1.5	−15.8
Feb. 22	2 3	22 19	+0.3	−10.5
Mar. 10	2 45	23 19	+2.0	− 4.7
Mar. 26	3 24	0 18	+3.6	+ 1.9
Apr. 11	4 3	1 16	+4.9	+ 8.0
Apr. 27	4 40	2 15	+5.8	+13.6
May 13	5 16	3 17	+6.3	+18.2
May 29	5 51	4 21	+6.3	+21.5
June 14	6 24	5 27	+5.8	+23.2
June 30	6 55	6 33	+5.0	+23.2

The table shows, that in the beginning of July, the Comet will be lost in the *Sun's* rays, and after this an Ephemeris would be useless, as the distance of the Comet from the *Earth* and the *Sun* will be so great that it will certainly be impossible to see it.

Concerning the calculations of the future brightness of the Comet, we must notice that it presents, as always, some difficulties. According to the observations of PROF. E. E. BARNARD at the Yerkes Observatory, the Comet is fainter than was to be expected. On Sept. 26 PROF. BARNARD found its brightness 13^{m}.

while, referring to the observations of the Comet 1899 — 1912, its brightness would be at this time about $10^m.5$. But this circumstance is not yet sufficient to decide on the diminution of the brightness of the Comet, as we must notice, that when it approaches perihelion, its brightness grows more rapidly than it would be expected from the formula

$$m = m_0 + 5(\log r\Delta - \log r_0 \Delta_0)$$

It was so in 1911 — 1912, and it will probably be the same again.

Moreover, in the comet itself there are probably some physical phenomena going on, owing to which its brightness may suddenly grow. Such a case happened the 20-21 March 1892, and also in January 1912. However, the general appearance of the Comet changes probably little: namely, as on its last appearings, and now, it always had a small starlike center.

Leaving aside any reasoning about the variation of the brightness and form of the Comet until the special article, I permit myself here only to mention, that in the first half of 1919, the Comet will have a general brightness approximately of 12^m — 13^m.

Concerning the closeness of the representation of the observed places of the Comet in 1918 by the system K'_9, it is a little less accurate than is desired. Taking into consideration the perturbations during the period Jan. 10, 1918 to Sept. 27, 1918, I obtained the following deviation of the theory from the observation, made by Prof. Barnard Sept. 25, 1918:

$$\begin{aligned} &1918 \text{ Sept. } 26.73 \quad (O - C)^s_\alpha \cos\delta = -\ 6^s.30 \\ & \text{ Sept. } 26.73 \quad (O - C)''_\delta \qquad\ \ = -31''.7 \end{aligned}$$

The cause of these considerable residuals is due to certain imperfections of the connection of the systems K', as the perturbations for the period 1891 July 10 — 1898 August 22, having been borrowed by me from the calculations of A. Thraen, are seemingly not quite exact and should be calculated again. On the other hand, the perturbations caused by *Venus* were not taken into consideration. These causes, in connection with the considerable values of the differential coefficients for 1918 Sept. 26.73:

$$\cos\delta\, \frac{\partial\alpha}{\partial M} = -5.616$$

$$\frac{\partial\delta}{\partial M} = -2.630$$

are sufficient to explain the residuals above mentioned.

In concluding this account I beg to thank sincerely Prof. Barnard for sending me his observations of the Comet and for his kind attention to me. I am also very grateful to the editor of the *Astronomical Journal* for having printed my articles.

Ephemeris for 0^h Berlin Mean Time

1918 - 1919	α_{true}	Diff.	δ_{true}	Diff.	log r	log Δ	Aber. Time
	h m s	m s	° ′ ″	′ ″			m s
Dec. 28	23 30 23.4	+11 16.5	−4 7 21	+ 3 44	0.2011	0.1806	12 36
Jan. 1	23 41 39.9	+11 15.6	−4 3 37	+ 7 12	0.2023	0.1903	12 53
5	23 52 55.5	+11 13.9	−3 56 25	+10 22	0.2038	0.2001	13 10
9	0 4 9.4	+11 11.2	−3 46 3	+13 13	0.2055	0.2100	13 27
13	0 15 20.6	+11 7.8	−3 32 50	+15 45	0.2075	0.2198	13 47
17	0 26 28.4	+11 4.1	−3 17 5	+18 2	0.2097	0.2296	14 6
21	0 37 32.5	+11 0.1	−2 59 3	+20 3	0.2122	0.2393	14 25
25	0 48 32.6	+10 56.0	−2 39 0	+21 47	0.2149	0.2490	14 45
29	0 59 28.6	+10 51.7	−2 17 13	+23 15	0.2178	0.2587	15 5
Feb. 2	1 10 20.3	+10 47.2	−1 53 58	+24 28	0.2209	0.2683	15 25
6	1 21 7.5	+10 42.3	−1 29 30	+25 22	0.2242	0.2778	15 45
10	1 31 49.8	+10 37.6	−1 4 8	+26 5	0.2277	0.2873	16 6
14	1 42 27.4	+10 32.7	−0 38 3	+26 32	0.2314	0.2966	16 27
18	1 53 0.1	+10 28.0	−0 11 31	+26 48	0.2352	0.3059	16 48
22	2 3 28.1	+10 23.4	+0 15 17	+26 52	0.2391	0.3150	17 10
26	2 13 51.4	+10 18.6	+0 42 9	+26 44	0.2432	0.3240	17 31
Mar. 2	2 24 10.0	+10 14.1	+1 8 53	+26 26	0.2474	0.3329	17 53
6	2 34 24.1	+10 9.5	+1 35 19	+25 56	0.2517	0.3417	18 15
10	2 44 33.6	+10 4.9	+2 1 15	+25 15	0.2561	0.3504	18 37
14	2 54 38.5	+10 0.2	+2 26 30	+24 29	0.2606	0.3589	18 59
18	3 4 38.7	+ 9 55.6	+2 50 59	+23 34	0.2651	0.3673	19 21

1918 - 1919	α_{true}	Diff.	δ_{true}	Diff.	Log r	log Δ	Aber. Time
	h m	m s	° ′ ″	′ ″			m s
Mar. 22	3 14 34.3	+ 9 51.0	+3 14 33	+22 33	0.2698	0.3756	19 43
26	3 24 25.3	+ 9 46.6	+3 37 6	+21 23	0.2744	0.3837	20 6
30	3 34 11.9	+ 9 42.0	+3 58 29	+20 9	0.2791	0.3917	20 28
Apr. 3	3 43 53.9	+ 9 37.4	+4 18 38	+18 47	0.2839	0.3995	20 51
7	3 53 31.3	+ 9 32.8	+4 37 25	+17 22	0.2887	0.4071	21 13
11	4 3 4.1	+ 9 27.9	+4 54 47	+15 52	0.2935	0.4147	21 35
15	4 12 32.0	+ 9 23.1	+5 10 39	+14 21	0.2983	0.4220	21 57
19	4 21 55.1	+ 9 18.2	+5 25 0	+12 46	0.3031	0.4292	22 19
23	4 31 13.3	+ 9 13.3	+5 37 46	+11 8	0.3080	0.4363	22 41
27	4 40 26.6	+ 9 8.3	+5 48 54	+ 9 28	0.3128	0.4432	23 3
May 1	4 49 34.9	+ 9 3.2	+5 58 22	+ 7 46	0.3176	0.4499	23 25
5	4 58 38.1	+ 8 57.9	+6 6 8	+ 6 3	0.3225	0.4564	23 46
9	5 7 36.0	+ 8 52.1	+6 12 11	+ 4 21	0.3273	0.4627	24 6
13	5 16 28.4	+ 8 46.8	+6 16 32	+ 2 38	0.3320	0.4689	24 26
17	5 25 15.2	+ 8 41.1	+6 19 10	+ 0 55	0.3368	0.4719	24 47
21	5 33 56.3	+ 8 35.5	+6 20 5	− 0 47	0.3415	0.4808	25 8
25	5 42 31.8	+ 8 29.8	+6 19 18	− 2 29	0.3462	0.4864	25 28
29	5 51 1.6	+ 8 23.6	+6 16 49	− 4 10	0.3509	0.4919	25 47
June 2	5 59 25.2	+ 8 18.0	+6 12 39	− 5 50	0.3556	0.4971	26 6
6	6 7 43.2	+ 8 11.4	+6 6 49	− 7 27	0.3602	0.5022	26 24
10	6 15 54.6	+ 8 5.1	+5 59 22	− 9 3	0.3648	0.5070	26 42
14	6 23 59.7	+ 7 58.7	+5 50 19	−10 34	0.3693	0.5118	27 0
18	6 31 58.4	+ 7 52.3	+5 39 45	−12 10	0.3738	0.5163	27 17
22	6 39 50.7	+ 7 45.9	+5 27 35	−13 38	0.3783	0.5205	27 33
26	6 47 36.6	+ 7 39.2	+5 13 57	−15 5	0.3827	0.5246	27 48
30	6 55 15.8	+ 7 32.4	+4 58 52	−16 29	0.3871	0.5285	28 3
July 4	7 2 48.2	+ 7 25.4	+4 42 23	−17 53	0.3914	0.5322	28 17
8	7 10 13.6		+4 24 30		9.3957	0.5356	28 31

Naval Observatory, Vladivostock, November, 1918.

EPHEMERIS OF *EROS* (433),

By FRANK E. SEAGRAVE.

Greenwich Midnight 1919	α	δ	Log r	Log Δ
	h m s	° ′ ″		
June 1	20 43 58	−27 18 32	0.24002	9.98026
5	20 43 13	−27 9 47	0.24134	9.96690
9	20 41 35	−27 2 6	0.24260	9.95385
13	20 39 6	−26 55 4	0.24372	9.94119
17	20 35 41	−26 48 11	0.24480	9.92920
21	20 31 21	−26 42 24	0.24578	9.91805
25	20 26 9	−26 35 31	0.24668	9.90805
29	20 20 7	−26 27 46	0.24752	9.89942
July 3	20 13 23	−26 18 32	0.24826	9.89239
7	20 6 1	−26 7 9	0.24888	9.88709
11	19 58 20	−25 53 23	0.24950	9.88396
15	19 50 22	−25 36 38	0.24998	9.88283
July 19	19 42 22	−25 17 21	0.25036	9.88383
23	19 34 33	−24 55 12	0.25072	9.88711
27	19 27 5	−24 31 1	0.25096	9.89244
31	19 19 24	−24 6 12	0.25114	9.89999
Aug. 4	19 13 56	−23 37 21	0.25122	9.90875
8	19 8 29	−23 9 7	0.25124	9.91930
12	19 3 53	−22 40 48	0.25116	9.93107
16	19 0 9	−22 12 43	0.25100	9.94384
20	18 57 19	−21 45 9	0.25078	9.95745
24	18 55 20	−21 18 26	0.25044	9.97159
28	18 54 13	−20 52 40	0.25006	9.98617

Opposition July 17, 1919.

CONTENTS

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward
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THE VERTEX OF STELLAR MOTIONS,

By Lewis Boss,*
Prepared for publication by H. Raymond.

Immediately after the completion of his third paper on "Precession and Solar Motion" (*A. J.*, 623-4), Professor Lewis Boss, in April, 1911, took up the study of the preferential motion. The research was practically completed, but was never published; the bare result was given in his report for the year 1911 (*C. I. W.*, *Yearbook*, 10, 158-9). It has seemed worth while, therefore, even at this late day, to present the details, partly because of its place in the history of the subject, but especially as an example of a very approximate solution of a complicated problem by a comparatively easy, partly graphical method.

The process was based upon charts of the proper-motions of the *Preliminary General Catalogue*. Each of these charts contains plotted points representing the proper-motions of the stars within a certain trapezium of the sky, referred in general to the direction of solar motion as initial line, and on a scale of 3″ per century to the inch. It is evident that composites can be made by simply copying two or more upon a single sheet with one origin and proper orientation. A number of such composites are figured in *A. J.*, 620 and 635-6.

The true vertex as found by Eddington (*M. N.*, 71, 4) was adopted as a first approximation. The charts were laid one by one upon a large paper protractor in such a manner that the parallactic center ($\theta = 180°$, $\rho = M \sin \Delta$) and the direction of the north galactic pole, — previously marked upon the charts, — coincided respectively with the center and zero of the protractor. Professor Boss then estimated the direction of elongation of the mass of plotted points, and read off its angle. Only charts of areas between 45° and 135° from Eddington's vertex were read.

The plotted velocity-points presented to the eye at least two classes — a loose but fairly definite cluster, more or less elongated, and some scattered outlying points or clumps of points. The latter class, representing the larger motions, showed generally the same tendency to elongation, but with greater uncertainty, being too few to form a continuous field. They were taken but slightly into account, the decision resting upon the oval cluster. In the charts having most points, this frequently had an inner nucleus containing a large fraction of the points in a small fraction of the area. The sharpness of the contrast resulted in part from the finite size of the plotted points, which caused them to encroach upon each other here, and the area of white paper to be disproportionately diminished. The nucleus showed in general the same characters as the cluster; where the two gave different position angles a compromise was made, taking into account the relative numbers.

The resulting material was solved for a new position of the Vertex by Argelander's method. If, L, B, are the galactic coördinates of the assumed Vertex; ΔL, ΔB their corrections; l, b, those of the given area; χ its distance from the Vertex; and $\Delta\phi$ the observed position angle minus that computed for the assumed Vertex; we have for the form of the conditional equation

$$(\sin B \cos \chi - \sin b)\,\Delta L - \cos b \sin (L - l)\,\Delta B - \sin^2 \chi\,\Delta\phi = 0$$

or, since $L = 166° 38'$, $B = 0$

$$\sin b{\cdot}\Delta L + \sin (166°.6 - l) \cos b{\cdot}\Delta B + \sin^2 \chi\,\Delta\phi = 0.$$

This differs from the usual form of Argelander's equation in containing an additional factor $\sin \chi$.

*At my request Mr. H. Raymond has prepared this paper for publication. It is very fitting that he should do so in view of the statement of Prof. Lewis Boss — "In working out these results, my assistants, H. Raymond and Benjamin Boss, have taken a part that justifies their admission, in some measure, as joint authors."
Benjamin Boss.

In other words, ARGELANDER gave $\Delta\phi$ the weight $\sin^2 \chi$. BOSS assigned $\sin^4 \chi$. This is because the determination of $\Delta\phi$ as ϕ departs from 90° falls off so much more rapidly in this problem than in that of Solar Motion.

There were 74 areas included in the program, but 101–104 and 105–108, about the Galactic Poles, were so scanty that they were each combined in one, while 34 and 43 were rejected because they contain the Apex and Antapex. A solution of the 66 equations by least squares gave

$$\Delta L = +4^\circ.11 \pm 0^\circ.99$$
$$\Delta B = -2^\circ.51 \pm 0^\circ.93$$

whence the position of the Vertex is (170°.74, −2°.51), or in equatorial cöordinates ($6^h\ 15^m.2$, +7°.0).

There is an excess of negative residuals amounting to 2°.6 in the mean. Removing it does not change the probable errors sensibly, the increase in the number of quantities to be determined offsetting the decrease in the sum of *prr*. There seems to be no obvious explanation of this excess, which is greater in northern latitudes. It is clear, however, that the discordances inherent in the charts, due to local streaming or other causes, are far more potent to produce large residuals than the errors of reading.

PROFESSOR BOSS had already estimated the ratio of axes in the velocity-figure at 7 : 4 (*A. J.*, 623-4, p. 192). He now proceeded to a revision of this estimate. As

TABLE I

Area	l	b	χ	ϕ Obs.	$\Delta\phi$	r
1	90°	0°	77°	77°	−13°	−16°
2	110	0	57	99	+ 9	+ 6
8	230	0	63	281	+11	+14
9	250	0	83	266	− 4	− 2
10	270	0	103	259	−11	− 8
11	290	0	123	264	− 6	− 3
17	50	0	117	91	+ 1	− 2
18	70	0	97	100	+10	+ 8
19	90	+20	77	88	− 7	− 8
20	110	20	59	102	− 1	− 2
25	210	20	17	245	− 5	+ 1
26	230	20	65	249	−11	− 7
27	250	20	81	260	− 8	− 4
28	270	20	103	270	− 5	1
29	290	20	121	275	− 8	− 3
35	50	20	115	77	− 3	− 4
36	70	+20	96	83	− 5	− 6
37	90	−20	77	88	+ 3	− 1
38	110	20	59	84	+ 7	+ 2
41	230	20	65	283	+ 3	+ 4
45	250	20	84	252	−20	−11
46	270	20	103	280	+15	+16
47	290	20	121	259	+ 2	+ 3
52	30	20	133	112	+ 2	− 4
53	50	20	115	95	− 5	−10
54	70	−20	96	107	+15	+11
55	103	+40	70	104	− 4	− 3
56	129	40	53	114	−15	−13
59	206	40	54	223	− 9	− 3
60	231	40	71	248	− 5	0
61	257	40	90	267	− 3	+ 2
62	283	40	110	294	+ 6	+11
63	309	40	127	293	−16	−10
66	26	40	138	35	−17	−15
67	51	40	109	75	+ 2	+ 3
68	77	+40	90	86	− 4	− 3
69	103	−40	70	79	+ 7	+ 2
70	129	40	53	55	+ 4	− 2
73	206	40	42	312	+ 4	+ 2
74	231	40	71	275	−12	−13
75	257	40	90	273	+ 3	+ 2
76	283	40	110	244	− 8	− 9
77	309	40	127	240	+ 9	+ 7
80	26	40	126	124	− 4	−10
81	51	40	109	114	+ 7	+ 2
82	77	−40	90	94	+ 4	0
83	90	+60	83	93	− 9	− 7
84	130	60	66	146	+ 7	+10
85	170	60	60	153	−31	−26
86	210	60	69	216	−11	− 6
87	250	60	87	250	−14	− 9
88	290	60	106	295	− 5	0
89	330	60	119	328	−13	− 8
90	10	60	117	21	− 6	− 2
91	50	+60	103	59	− 8	− 5
92	90	−60	83	87	+11	+ 4
93	130	60	66	52	52	+ 6
94	170	60	60	7	+11	+ 6
95	210	60	69	309	− 4	− 7
96	250	60	87	265	−11	−13
97	290	60	106	243	+3	0
98	330	60	119	180	−19	−23
99	10	60	117	140	−13	−18
100	50	−60	103	124	+11	+ 6
101 — 4	. . .	+90	90	283	+ 1	+ 5
105 — 8	. .	−90	90	74	− 4	− 8

it was plain that charts of single areas would not suffice, composites were formed, in general of four, of equal galactic latitudes (*plus* or *minus*), and sin χ. The exact combinations may be seen in Table II. The parallactic center and direction of vertex on all four were made to agree, but a chart was copied direct or inverted (*i. e.*, through the paper) according as $\tan b \cdot \tan (L - l)$ agrees or disagrees in sign with the lowest numbered area of the four. PROFESSOR BOSS by eye laid out upon these charts ovals of essentially equal density, and measured their length a and breadth b. The size of these "axes" depends upon the number and distance of the stars concerned, but their ratio is a function only of the form and orientation of the velocity-ellipsoid. These measures, the ratios a/b, and sin χ are exhibited in Table II.

Grouping 23 of the 26 composites according to sin χ, and taking means of a, b, and χ, he had

TABLE II

Group	a	b	a/b	sin χ
	"	"		
1 — 9 — 10 — 18	25.5	11.5	2.22	.985
2 — 8 — 11 — 17	21.5	13.0	1.65	.866
3 — 7 — 12 — 16	25.0	12.5	2.00	.643
4 — 6 — 13 — 15	23.5	14.0	1.68	.345
5 — 14	15.0	13.0	1.15	.046
19 — 28 — 37 — 46	24.5	14.5	1.69	.998
20 — 29 — 38 — 47	23.0	15.5	1.48	.888
21 — 30 — 39 — 48	24.0	13.0	1.85	.703
22 — 31 — 40 — 49	19.0	15.0	1.27	.477
23 — 32 — 41 — 50	19.5	15.0	1.30	.342
24 — 33 — 42 — 51	20.0	14.0	1.43	.462
25 — 34 — 43 — 52	23.0	15.5	1.48	.686
26 — 35 — 44 — 53	24.5	14.5	1.69	.877
27 — 36 — 45 — 54	22.0	15.0	1.47	.983
55 — 62 — 69 — 76	27.0	15.5	1.74	.958
56 — 63 — 70 — 77	27.0	17.0	1.59	.823
57 — 64 — 71 — 78	23.0	16.0	1.44	.674
58 — 65 — 72 — 79	23.5	20.0	1.18	.667
59 — 66 — 73 — 80	25.0	18.0	1.39	.779
60 — 67 — 74 — 81	23.0	15.0	1.53	.927
61 — 68 — 75 — 82	24.0	15.5	1.55	.999
83 — 87 — 92 — 96	29.0	14.5	2.00	.996
84 — 86 — 93 — 95	24.0	16.5	1.45	.924
85 — 89 — 90 — 94 — 98 — 99	26.0	16.5	1.58	.877
88 — 91 — 97 — 100	25.5	18.5	1.38	.968
101 to 108	25.5	16.0	1.59	.992

Group	No. Areas	sin χ	a/b	A/B
I	9	.927 – .999	1.66	1.68
II	7	.779 – .924	1.54	1.68
III	7	.462 – .703	1.49	2.00

He concluded that the preliminary ratio, 7 : 4, was very nearly correct. He also grouped the same material according to galactic latitudes. Taking the means of a/b and sin χ, this gives

Galactic Lat.	Areas	a/b	A/B
0° — 10°	3	1.96	2.26
10 — 30	8	1.54	1.85
30 — 50	7	1.49	1.66
50 — 90	5	1.60	1.65

The progression with galactic latitude indicates that the axis perpendicular to the galactic plane is the smallest.

A/B is derived from a/b through SCHWARZSCHILD's equation

$$\sin\chi\cdot\sqrt{A^2/B^2-1} = \sqrt{a^2/b^2-1}$$

It seemed worth while to make a least square solution on the basis of this equation. Taking the first radical as the unknown and the second as the quantity given by measurement, all the data of Table II gives the values of A/B following in column I. Squaring the equation, so as to give less weight to the areas near the vertex and antivertex, we have the values of A/B given in column II.

Lat.	Areas	I	II
0° — 10°	5	2.31	2.21
10 — 30	9	1.80	1.74
30 — 50	7	1.65	1.66
50 — 90	5	1.64	1.67
0 — 30	14	1.96	1.90
30 — 90	12	1.65	1.66
0 — 90	26	1.777 ±.049	1.765 ±.045

This seems to indicate three unequal axes in about the ratio

$$A:B:C = 2.2:1.3:1$$

POSITIONS OF COMPARISON STARS FOR THE COMET 1913*f*.

OBSERVED WITH THE LA PLATA MERIDIAN CIRCLE,

BY P. T. DELAVAN

The following is a complete list of the southern comparison stars for the comet 1913*f* which have recently been observed with the large Gautier Meridian Circle. Except in a few cases each star has been observed twice and in opposite positions of the instrument. The positions, which are reduced to the system of the *Berliner Jahrbuch*, have been corrected for the effect of magnitude equation. The mean probable errors of a single observation are $\pm 0^s.025 \sec\delta$ and $\pm 0''.36$.

No.	Mag.	R. A. 1914.0	Prec.	Dec. 1914.0	Prec.	Epoch	Designation	
1	7.8	2 34 58.08	+3.037	− 2 26 36.5	+15.63	16.9	*A.G. Stras.*	647
2	3.9	2 35 4.38	3.073	0 2 30.8	15.63	16.9	δ *Ceti*	
3	8.3	2 36 19.32	3.039	2 17 37.0	15.56	16.9	*A.G. Stras.*	651
4	5.9	2 36 49.46	3.057	1 3 39.1	15.53	16.9	Boss *P.G.C.*	612
5	8.8	2 36 54.61	3.049	1 36 42.1	15.53	16.9	*A.G. Stras.*	653
6	7.8	2 36 57.16	+3.066	− 0 27 40.9	+15.53	16.9	*A.G. Nic.*	551
7	6.3	2 37 28.42	3.020	3 34 50.9	15.50	16.9	*A.G. Stras.*	655
8	9.0	2 37 42.37	3.059	0 58 27.0	15.48	17.9	*A.G. Nic.*	555
9	9.0	2 37 56.72	3.033	2 43 9.2	15.47	16.9	*A.G. Stras.*	656
10	9.1	2 38 21.90	3.067	0 23 20.8	15.45	16.9	*B.D.* −0°	413
11	9.0	2 38 54.69	+3.051	− 1 30 1.3	+15.42	16.9	*A.G. Nic.*	559
12	8.5	2 38 57.42	3.055	1 13 24.9	15.41	16.9	*A.G. Nic.*	560
13	6.7	2 39 7.90	3.030	2 53 48.1	15.40	16.9	*A.G. Stras.*	661
14	8.6	2 39 13.49	3.062	0 42 32.3	15.40	17.0	*A.G. Nic.*	562
15	8.4	2 40 9.24	3.052	1 24 46.6	15.35	16.9	*A.G. Nic.*	566
16	8.3	2 40 18.30	+3.038	− 2 19 31.7	+15.34	16.9	*A.G. Stras.*	664
17	9.1	2 40 19.71	3.055	1 12 34.7	15.34	16.9	*A.G. Nic.*	567
18	8.8	2 40 36.68	3.065	0 33 17.3	15.32	16.9	*A.G. Nic.*	569
19	9.2	2 40 51.80	3.037	2 23 2.4	15.30	17.0	*B.D.* −2°	482
20	9.1	2 40 53.31	3.022	3 23 58.3	15.30	17.0	*B.D.* −3°	431
21	9.2	2 41 36.91	+3.025	− 3 12 15.5	+15.26	17.9	*B.D.* −3°	432
22	8.5	2 42 10.07	3.047	1 44 41.6	15.23	16.9	*A.G. Stras.*	667

No.	Mag.	R. A. 1914.0	Prec.	Dec. 1914.0	Prec.	Epoch	Designation	
23	9.0	2 42 25.88	+3.012	− 2 0 24.5	+15.22	16.9	*A.G. Stras.*	668
24	8.6	2 42 48.24	3.018	3 35 11.4	15.20	16.9	*A.G. Stras.*	669
25	8.5	2 43 5.45	3.017	3 39 22.7	15.20	16.9	*A.G. Stras.*	670
26	9.0	2 43 14.39	+3.028	− 2 56 30.1	+15.17	17.0	*A.G. Stras.*	671
27	7.3	2 43 53.76	3.012	3 58 37.4	15.13	16.9	*A.G. Stras.*	672
28	8.3	2 44 5.50	3.022	5 16 44.1	15.12	17.9	*A.G. Stras.*	675
29	8.3	2 44 29.65	3.044	1 52 16.6	15.10	16.9	*A.G. Stras.*	676
30	8.0	2 44 38.36	2.988	5 31 33.7	15.09	16.9	*A.G. Stras.*	677
31	7.0	2 44 44.17	+3.003	− 4 34 55.0	+15.08	17.9	*A.G. Stras.*	678
32	9.1	2 44 44.62	3.004	4 27 8.1	15.08	17.0	*A.G. Stras.*	679
33	8.7	2 45 23.20	3.013	3 54 15.0	15.04	16.9	*A.G. Stras.*	680
34	8.6	2 45 43.29	2.994	5 4 10.1	15.03	17.9	*A.G. Stras.*	681
35	7.2	2 46 4.17	2.990	5 20 30.6	15.01	16.9	*A.G. Stras.*	683
36	7.7	2 47 2.30	+3.021	− 3 21 5.7	+14.95	16.9	*A.G. Stras.*	684
37	8.9	2 47 10.42	2.997	4 52 37.1	14.95	16.9	*A.G. Stras.*	685
38	9.0	2 47 29.54	3.013	3 49 22.8	14.92	16.9	*A.G. Stras.*	686
39	7.3	2 48 55.86	2.985	5 36 1.5	14.84	16.8	*A.G. Stras.*	690
40	7.5	2 49 24.98	3.001	4 35 53.7	14.81	16.9	*A.G. Stras.*	694
41	7.0	2 50 21.81	+2.983	− 5 40 46.7	+14.75	16.8	*A.G. Stras.*	697
42	8.8	2 52 20.86	2.967	6 35 58.8	14.64	16.8	*A.G. Wien Ott.*	662
43	8.0	2 52 24.50	2.982	5 41 56.2	14.63	16.9	*A.G. Stras.*	705
44	9.0	2 52 25.48	2.977	6 1 1.2	14.63	16.9	*A.G. Wein Ott.*	664
45	9.4	2 54 56.49	2.972	6 12 22.8	14.48	16.9	*B.D.* −6°	578
46	9.4	2 55 0.79	+2.966	− 6 35 13.2	+14.48	16.8	*A.G. Wein Ott.*	670
47	8.9	2 55 56.08	2.969	6 25 11.1	14.42	16.9	*A.G. Wein Ott.*	677
48	8.8	2 56 23.50	2.960	6 55 19.4	14.39	16.9	*A.G. Wein Ott.*	681
49	9.1	2 56 42.99	2.967	6 30 22.9	14.37	16.9	*B.D.* −6°	585
50	6.3	2 57 53.90	2.961	6 49 47.6	14.30	16.8	*A.G. Wein Ott.*	685
51	8.8	2 58 1.93	+2.972	− 6 8 43.9	+14.29	16.9	*A.G. Wein Ott.*	686
52	9.0	3 0 8.83	2.954	7 11 48.1	14.16	16.8	*A.G. Wein Ott.*	696
53	8.2	3 2 24.67	2.956	6 58 31.1	14.02	16.8	*A.G. Wein Ott.*	706
54	9.5	3 4 49.87	2.945	7 23 36.6	13.88	16.8	*A.G. Wein Ott.*	719
55	9.1	3 6 24.39	2.947	7 23 17.5	13.77	16.8	*A.G. Wein Ott.*	728
56	9.3	14 43 54.98	+4.202	−52 8 55.8	−15.13	16.4	*C.P.D.* −51°	7198
57	8.0	14 44 15.02	4.199	52 1 41.6	15.11	16.4	*C.P.D.* −51	7204
58	9.6	14 45 40.19	4.218	52 17 11.0	15.03	16.5	*C.P.D.* −52	7575
59	9.2	14 46 6.58	4.209	52 1 37.0	15.00	16.4	*C.P.D.* −51	7241
60	8.9	14 46 35.16	4.208	51 55 23.8	14.98	16.4	*C.P.D.* −51	7246
61	9.6	14 46 56.78	+4.201	−51 42 40.1	−14.96	16.5	*C.P.D.* −51°	7254
62	9.2	14 48 1.07	4.202	51 34 56.6	14.89	16.4	*C.P.D.* −51	7277
63	8.4	14 48 5.53	4.254	52 50 46.7	14.88	14.9	*C.P.D.* −52	7609
64	7.0	14 53 14.86	4.216	51 13 54.9	14.58	16.4	*C.P.D.* −51	7374
65	9.1	14 53 28.31	4.322	53 39 7.0	14.57	16.4	*C.P.D.* −53	6180

No.	Mag.	R. A. 1914.0	Prec.	Dec. 1914.0	Prec.	Epoch	Designation	
66	8.9	14 54 21.99	+4.330	−53 43 22.2	−14.52	16.4	*C.P.D.* −53°	6186
67	9.1	14 56 37.77	4.350	53 52 30.8	14.38	16.5	*C.P.D.* −53	6207
68	9.3	14 57 23.98	4.362	54 2 16.8	14.33	16.4	*C.P.D.* −53	6222
69	8.7	14 57 44.89	4.362	54 0 7.0	14.31	16.4	*C.P.D.* −53	6229
70	8.8	14 58 16.73	4.239	51 10 5.3	14.28	16.4	*C.P.D.* −51	7488
71	9.0	14 59 57.43	+4.383	−54 10 38.6	−14.17	16.4	*C.P.D.* −54°	6320
72	9.2	15 1 27.60	4.393	54 13 7.9	14.08	16.4	*C.P.D.* −54	6333
73	9.7	15 1 37.29	4.258	51 11 47.1	14.07	16.6	*C.P.D.* −51	7552
74	8.7	15 1 53.01	4.258	51 10 42.0	14.05	16.4	*C.P.D.* −51	7557
75	9.6	15 3 40.67	4.409	54 15 35.8	13.94	16.4	*C.P.D.* −54	6359
76	8.9	15 5 4.90	+4.423	−54 23 51.7	−13.85	16.4	*C.P.D.* −54°	6369
77	8.7	15 9 13.98	4.472	54 54 3.6	13.59	16.4	*C.P.D.* −54	6414
78	8.4	15 12 46.21	4.509	55 12 50.6	13.36	16.4	*C.P.D.* −54	6490
79	9.5	15 18 11.56	4.531	55 5 1.6	13.00	16.4	*C.P.D.* −54	6486
80	8.0	15 22 24.41	4.568	55 19 43.5	12.72	16.4	*C.P.D.* −55	6572
81	9.4	15 28 52.45	+4.605	−55 23 14.3	−12.28	16.4	*C.P.D.* −55°	6624
82	8.4	15 42 40.81	4.669	55 19 15.1	11.30	16.4	*C.P.D.* −55	6719
83	8.3	15 45 50.39	4.682	55 17 49.7	11.07	15.5	*C.P.D.* −55	6741
84	9.2	15 48 3.96	4.695	55 19 55.6	10.91	16.4	*C.P.D.* −55	6780
85	8.8	15 53 28.68	4.719	55 18 57.2	10.50	16.4	*C.P.D.* −55	6898
86	8.4	15 54 15.35	+4.726	−55 23 16.3	−10.45	15.5	*C.P.D.* −55°	6916
87	8.8	15 57 56.00	4.730	55 11 15.4	10.17	16.4	*C.P.D.* −55	7009
88	8.1	16 3 41.16	4.750	55 7 11.4	9.73	16.4	*C.P.D.* −55	7159
89	7.5	16 17 37.30	3.254	8 32 19.1	8.65	16.4	*A.G. Wein Ott.*	5677
90	8.8	16 22 27.79	4.772	54 21 47.7	8.27	15.5	*C.P.D.* −54°	7719
91	8.2	16 24 14.23	+3.185	−5 15 20.4	− 8.13	16.5	*A.G. Stras.*	5674
92	8.3	16 24 35.26	3.186	5 15 43.9	8.10	16.4	*A.G. Stras.*	5665
93	7.5	16 27 10.78	3.220	6 50 20.0	7.89	16.4	*A.G. Wein Ott.*	5724
94	8.8	16 28 52.95	4.777	54 6 31.7	7.75	16.4	*C.P.D.* −54°	7761
95	8.0	16 29 34.52	4.774	54 22 22.5	7.70	16.4	*C.P.D.* −53°	8076
96	8.4	16 30 42.39	+3.241	− 7 45 30.7	− 7.61	16.5	*A.G. Wein Ott.*	5736
97	7.9	16 33 43.62	4.782	53 58 2.0	7.36	15.5	*C.P.D.* −53°	8122
98	6.6	16 34 7.19	3.258	8 26 52.2	7.33	16.4	*A.G. Wein Ott.*	5754
99	6.9	16 34 56.74	3.279	9 22 52.3	7.27	16.6	*A.G. Wein Ott.*	5757
100	9.0	16 35 35.56	3.276	9 16 20.2	7.26	16.5	*A.G. Wein Ott.*	5761
101	8.5	16 36 11.70	+4.771	−53 39 50.1	− 7.16	15.5	*C.P.D.* −53°	8147
102	6.8	16 36 16.51	3.252	8 8 35.6	7.16	16.4	*A.G. Wein Ott.*	5764
103	9.1	16 38 31.13	3.289	9 13 11.1	6.97	16.5	*B.D.* −9°	4439
104	8.4	16 40 18.90	4.773	53 29 52.4	6.78	15.5	*C.P.D.* −53°	8176
105	8.8	16 45 50.69	4.764	53 8 29.0	6.36	16.4	*C.P.D.* −53°	8205
106	8.6	16 51 55.53	+4.745	−52 35 44.1	− 5.86	15.0	*C.P.D.* −52°	10360
107	6.7	16 56 19.86	3.380	13 26 0.3	5.49	16.4	*A.G. Cbr.*	5826
108	9.2	16 59 22.10	3.105	14 26 10.2	5.23	16.4	*B.D.* −14°	4532

No.	Mag	R. A. 1914.0	Prec.	Dec. 1914.0	Prec.	Epoch	Designation	
109	9.0	16 59 42.82	+3.406	−14 27 7.8	−5.20	16.5	*A.G. Wash.*	6103
110	8.8	17 10 59.42	3.465	16 42 23.7	4.25	16.5	*A.G. Wash.*	6179
111	8.8	17 12 14.77	+4.651	−50 20 16.5	−4.13	16.5	*C.Z.*	610
112	8.0	17 15 45.92	4.620	49 40 35.0	3.83	16.4	*Arg. G.*	23462
113	8.3	17 16 7.33	4.625	49 17 29.4	3.80	16.4	*C. Z.*	898
114	8.8	17 17 26.58	3.526	19 1 12.2	3.70	16.5	*B.D.* −18°	4508
115	7.4	17 17 29.22	4.601	49 18 30.4	3.61	16.5	*C. Z.*	992
116	8.6	17 18 47.41	+4.606	−49 22 18.2	−3.57	16.4	*Arg. G.*	23540
117	8.2	17 19 16.24	4.596	49 19 30.8	3.53	16.5	*C.P.D.* −49°	9981
118	8.6	17 20 20.07	4.602	49 15 56.4	3.44	16.4	*C. Z.*	1173
119	8.6	17 22 7.50	3.559	20 14 28.7	3.29	16.4	*B.D.* −20°	4771
120	8.9	17 23 34.56	4.567	48 32 40.2	3.16	16.4	*C. Z.*	1394
121	9.0	17 26 6.54	+4.558	−48 19 21.0	−2.94	16.4	*C. Z.*	1565
122	8.6	17 26 16.97	4.561	48 26 15.5	2.93	16.5	*C.P.D.* −48°	9282
123	9.0	17 26 17.67	3.594	21 30 0.5	2.93	16.5	*B.D.* −21°	4628
124	8.2	17 28 20.66	4.534	47 49 14.2	2.75	16.4	*Arg. G.*	23790
125	8.0	17 31 33.05	4.472	46 31 55.0	2.47	16.4	*C. Z.*	1947
126	8.7	17 36 29.41	+4.413	−45 13 40.7	−2.04	16.4	*Arg. G.*	23962
127	8.5	17 36 42.86	3.745	26 18 7.9	2.01	18.6	*Cape* 00	2410
128	7.5	17 37 14.49	4.447	45 55 19.9	1.98	16.4	*Cape Ast.*	6384
129	8.0	17 38 38.33	4.409	45 8 55.7	1.85	16.4	*Arg. G.*	24022
130	10.0	17 39 12.25	3.708	25 31 3.4	1.81	16.5	*C.P.D.* −25°	6054
131	8.9	17 39 37.12	+3.684	−24 38 49.3	−1.77	16.4	*C. Z.*	2536
132	9.0	17 40 18.35	3.740	26 36 51.5	1.70	18.6	*Cape* 90	2157
133	8.8	17 40 57.97	3.736	26 28 19.9	1.65	16.5	*Co. D.* −26°	12323
134	9.0	17 41 19.77	3.718	25 50 36.9	1.62	16.5	*C.P.D.* −25°	6070
135	8.8	17 41 23.35	3.715	25 43 17.7	1.62	18.7	*Cape* 00	2420
136	8.2	17 41 34.44	+4.383	−44 30 40.6	−1.60	16.5	*Cape Ast.*	6411
137	7.0	17 42 8.68	3.776	27 47 55.9	1.54	18.7	*Cape* 00	2421
138	8.5	17 42 12.70	3.732	26 18 57.7	1.53	14.0	*Wash.*	15402
139	9.0	17 42 18.36	4.405	44 59 52.4	1.55	18.8	*C. Z.*	2676
140	8.5	17 42 18.57	4.374	44 18 39.7	1.53	16.5	*Arg. G.*	24117
141	7.5	17 43 5.01	+3.751	−26 56 43.4	−1.46	16.4	*Cape* 80	9691
142	8.8	17 43 22.14	3.752	26 58 39.4	1.44	16.5	*Argr.*	17227
143	9.2	17 43 51.02	3.772	27 39 33.2	1.40	16.5	*C.P.D.* −27°	5786
144	8.5	17 43 59.44	3.821	29 17 13.0	1.40	18.7	*Cape* 00	2424
145	8.8	17 44 13.88	3.763	27 22 13.4	1.37	16.5	*C.P.D.* −27°	5793
146	8.7	17 44 37.90	+4.322	−43 7 19.6	−1.34	16.4	*Cape Ast.*	6429
147	8.5	17 44 43.06	3.746	26 47 5.5	1.33	18.8	*Cape* 00	2427
148	9.0	17 44 53.52	3.754	27 2 14.1	1.33	18.7	*Cape* 00	2428
149	7.0	17 44 58.15	3.753	27 2 6.3	1.32	16.4	*Arg. G.*	24210
150	7.0	17 45 40.33	3.860	30 31 57.6	1.25	18.7	*Wash.*	3559
151	8.8	17 45 43.80	+3.763	−27 22 10.8	−1.25	16.5	*Co. D.* −27°	12009

No.	Mag.	R. A. 1914.0	Prec.	Dec. 1914.0	Prec.	Epoch	Designation	
152	8.6	17 46 25.68	+3.800	−28 35 59.2	−1.19	16.5	*Yarnall*	7581
153	7.2	17 46 42.83	3.884	31 18 21.7	1.16	18.8	*Wash.*	3567
154	6.9	17 46 43.71	4.273	41 58 14.7	1.16	16.4	*Cape Ast.*	6441
155	8.6	17 47 3.77	4.284	42 13 27.4	1.13	16.4	*C. Z.*	2994
156	9.0	17 47 38.14	+3.808	−28 50 47.5	−1.08	18.7	*Wash.*	3576
157	9.5	17 47 42.82	3.808	28 50 58.6	1.07	18.7	*Wash.*	3577
158	9.5	17 48 9.80	3.824	29 22 6.4	1.03	16.5	*C. Z.*	3087
159	6.8	17 48 10.51	3.761	27 15 50.2	1.03	18.7	*Cape* 00	2440
160	8.6	17 48 12.70	3.808	28 50 8.9	1.03	18.8	*Wash.*	3582
161	9.5	17 48 20.20	+3.821	−29 22 7.5	−1.02	16.5	*C. Z.*	3101
162	8.7	17 48 38.68	3.870	30 50 35.0	0.99	16.5	*C.P.D.* −30°	5012
163	9.2	17 49 0.81	4.248	41 20 58.3	0.96	16.5	*C.P.D.* −41°	8368
164	7.8	17 49 59.61	4.205	40 17 43.0	0.87	18.7	*Cape Ast.*	6461
165	8.2	17 50 47.71	4.209	40 22 21.1	0.80	16.4	*C.P.D.* −40°	8106
166	7.2	17 50 50.31	+4.190	−39 55 11.7	−0.80	16.4	*Arg. G.*	24328
167	7.8	17 50 53.86	4.205	40 17 34.4	0.80	16.5	*Arg. G.*	24330
168	8.3	17 50 57.24	3.991	34 31 6.6	0.79	16.5	*Arg. G.*	24331
169	7.0	17 51 11.88	3.930	32 40 34.7	0.77	16.5	*Arg. G.*	24340
170	8.8	17 51 25.83	4.187	39 49 49.4	0.75	16.5	*Co. D.* −39°	12042
171	8.5	17 51 52.96	+3.909	−32 2 19.0	−0.71	16.5	*Arg. G.*	24359
172	8.3	17 52 40.91	4.010	35 3 23.6	0.64	16.4	*Arg. G.*	24380
173	8.5	17 52 42.34	4.115	37 57 53.3	0.64	16.4	*Arg. G.*	24378
174	9.0	17 52 43.73	3.937	32 54 1.5	0.63	18.6	*C. Z.*	3888
175	6.5	17 53 5.01	4.074	36 51 0.9	0.61	16.5	*Perth V.*	1525
176	5.8	17 53 11.57	+3.806	−28 45 1.3	−0.59	18.7	*Cape* 00	2452
177	7.5	17 53 14.57	4.138	38 33 54.5	0.59	16.5	*Arg. G.*	24391
178	7.5	17 53 22.50	4.077	36 55 52.6	0.58	18.8	*Arg. G.*	24396
179	9.0	17 53 26.50	4.112	37 52 26.0	0.57	18.7	*C. Z.*	3425
180	9.0	17 53 28.69	4.047	36 5 16.7	0.57	16.5	*Co. D.* −36°	12066
181	5.4	17 53 33.99	+3.852	−30 14 44.4	−0.56	18.7	*Wash.*	3602
182	8.0	17 54 4.24	4.088	37 15 51.8	0.51	16.5	*C. Z.*	3468
183	7.5	17 54 16.24	3.954	33 24 7.3	0.50	14.0	*Arg. G.*	24423
184	9.0	17 54 16.48	4.041	35 55 18.5	0.50	18.7	*C. Z.*	3484
185	8.5	17 54 24.51	4.031	35 38 35.8	0.49	18.6	*C. Z.*	3497
186	8.8	17 54 24.74	+3.998	−34 40 55.1	−0.49	16.4	*Arg. G.*	24429
187	9.0	17 54 31.04	4.046	35 56 54.2	0.48	16.5	*C. Z.*	3502
188	9.0	17 54 40.77	4.001	34 46 50.7	0.46	16.5	*C.P.D.* −34°	7490
189	8.0	17 54 44.70	3.841	29 53 14.2	0.46	18.7	*Cape* 00	2458
190	8.5	17 55 1.95	3.998	34 42 12.2	0.43	16.5	*C. Z.*	3541
191	8.9	17 55 41.19	+3.932	−32 43 56.5	−0.38	16.5	*Arg. G.*	24462

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MEASURES OF DOUBLE STARS

By E. D. ROE, Jr.

The following pairs of stars, with a few exceptions, were found in searching for new pairs. Some of them were merely observed long enough to identify them.

J 584 *B.D.* +17° 62

0h 26m 32s, +17° 26′ (1920)

This position is given by J.

(9, 12) (14/10/18; 24-in.)

	°
1918.786	174.1

J 183 *A.G. Berlin* A. 146

0h 26m 41s, +15° 30′ (1880)

0h 28m 45s, +15° 44′ (1920)

(7.3, 13) (14/10/18; 24-in.)

	°	″
1918.786	102.1	22.12

426 η *Cassiopeiæ* (6½-in.)

1917.838	256.0	7.26
.844	255.0	.30
.847	255.8	.18
1917.843	255.6	7.25

531 *A.G.* 12 (9, 9.7) (6½-in.)

1917.871	242.7	4.73	
1902.800	243.4	4.48	M 3

Probably no change.

807 H 640 (9.7, 9.8) (6½-in.)

1917.912	104.9	5.86	
1820.+	295±	4.±	H
1901.81	290.7	5.31	β 2 (9.5, 9.5)
1910.766	110.5	5.69	Fox 3

1211 Σ 250 (9, 9.2) (6½-in.)

1917.912	134.7	3.20	
1832.01	135.8	3.16	Σ 3
1904.90	135.3	2.91	β 2

A 1705 *B.D.* +42° 748

3h 13m 3s, +42° 55′ (1880)

3h 15m 13s, +43° 4′ (1920)

21s.5 preceding and 1′.8 north of *A.G. Bonn* 2796 which was used in determining the position.

(9.6, 9.8) (19/11/17; 6½-in.)

	°	″	
1917.880	184.9	3.53	
1907.85	187.6	3.15	(9.5, 9.5) A 2

A 2420 *B.D.* +17° 795

3h 31m 36s, +17° 12′ (1880)

3h 33m 53s, +17° 20′ (1920)

This is *A.G. Berlin* A. 976 from which the positions were found.

(8.8, 9.5) (7/12/17; 6½-in.)

1917.934	269.7	1.29	
1912.69	268.4	1.80	(8.5, 9.5) A 2

Change doubtful.

3596 *Sirius* (1/3/18; 6½-in.)

1918.164	72.8	10.59

One setting each for angle and distance. This is not given as a measure, but merely as a record of an observation with this aperture. No doubt about seeing the companion.

5713 Σ 1518 rej. *BC*

11h 8m 11s, +5° 55′ (1880)

11h 10m 15s, +5° 42′ (1920)

6s.9 preceding and 0′.43 south of *A.G. Leip. II.* 5738.

(10, 10.5) (6½-in.)

	°	″
1918.040	350.	2.00
.370	351.1	3.04
.372	350.3	2.89
1918.261	350.6	2.64

This with other measures shows there is no decided evidence of change.

7717 ζ *Herculis* (6½-in.)

1918.480	92.3	1.71
.485	93.2	1.81
.488	93.5	1.85
1918.184	93.0	1.79

7769 Σ 2104 (6½-in.)

1918.480	20.2	5.33	
1825.35	19.5	5.86	Σ 3
1868.88	19.7	5.80	Δ 5
1889.52	17.9	5.69	Giacomelli 3

7858 Σ 2120 (6½-in.)

1918.485	238.7	10.50
.488	238.0	10.45
.501	237.7	9.84
1918.491	238.1	10.26

7911 α *Herculis* (6½-in.)

1918.525	112.5	4.55

8017 Σ 2165 (6½-in.)

1918.501	55.6	8.19

One setting each for angle and distance.

8160 Σ 2217 (6½-in.)

	°	″
1918.567	283.8	6.58

One setting each for angle and distance.

8318 Σ 2276 (6½-in.)

1918.542	256.0	6.92

One setting.

8532 Hu 64 (8, 9) (6½-in.)

1918.583	12.2	3 (estimated)
1899.65	12.1	4.04 Hu 1

8615 Σ 2329 (6½-in.)

1918.594	44.5	3.59

One setting.

8612 Σ 2339 (8, 8.5) (6½-in.)

1918.597	271.6	2.13
1830.03	271.5	2.33 (7.2, 8) Σ 3
1901.61	270.6	2.45 Hu 2

J 523 *B.D.* +9° 3790
18ʰ 32ᵐ 1ˢ, +9° 40′ (1880)
18ʰ 33ᵐ 54ˢ, +9° 42′ (1920)

22ˢ.6 preceding and 1′.56 south of *A.G. Leip. II.* 8701 which was used in determining the positions. J gives 18ʰ 33ᵐ 57ˢ (1920).

(9.9, 10.1) (17/7/18; 6½-in.)

1918.542	23.9	4.00
.548	22.8	3.76
.549	21.4	4.31
1918.561	21.7	4.02

8836 Σ 2401 (7, 8) (6½-in.)

1918.501	37.3	1.70 (one setting)
1828.80	37.6	1.06 Σ 1

Practically unchanged.

8860 Σ 2404 (26/7/18; 6½-in.)

1918.567	182.7	3.75
1829.09	183.2	3.53 Σ 3
1902.41	182.8	3.63 Hu 3

8876 Σ 2408 (26/7/18; 6½-in.)

1918.567	92.7	2.16
1830.70	96.5	2.30 Σ 3
1902.44	94.0	2.36 Hu 3

9117 A 99 *B.D.* −9° 5067
19ʰ 9ᵐ 49ˢ, −9° 38′ (1880)
19ʰ 12ᵐ 1ˢ, −9° 34′ (1920)

22ˢ.3 preceding and 0′.08 north of *A.G. Wien-Ottakring* 6658 which was used to get the position.

(9.7, 10.1) (1/8/18; 6½-in.)

	°	″
1918.583	72.0	1.81
.594	73.3	2.44
1918.589	72.7	2.13
1900.49	67.1	1.96 (10, 10) A 3

I measure from A to a third star 9.4, which is *B.D.* −9° 5068.

1918.594	81.3	43.04

9371 β *Cygni* (6½-in.)

1917.868	54.6	34.64 (daylight)
.871	.1	.65
1917.870	54.4	34.65

10363 β *Delphini* (6½-in.)

1918.580	157.3	
.606	158.7	0.38
.619	158.3	.45

These were all single settings and are not published as measures but only as a record of observations with this aperture. For comparison I give a single setting I made with the 24-in.

1918.726	159.4	0.39

J 191 20ʰ 35ᵐ 22ˢ, +17° 12′ (1880)
20ʰ 37ᵐ 12ˢ, +17° 21′ (1920)

1ˢ.8 preceding and 3′.73 north of *A.G. Berlin, A.* 8321. J gives 1ˢ more in the R. A. for 1920.

(9.5, 9.7) (31/7/18; 6½-in.)

1918.580	61.8	3.77
.606	61.4	3.50
.619	62.8	4.28
1918.602	62.0	3.85
1910.83	63.1	3.59 (9.3, 9.6) J 2
1915.77	65.7	4.34 (9.5, 9.8) J 1

Motion not yet indicated.

10538 β 66 (9.2, 9.2) (3/7/18; 6½-in.)

	°	″
1918.504	162.3	1.48
1876.00	158.9	1.23 Δ 5
1898.70	159.5	1.16 Doo 4

J 162 *B.D.* +13° 4717
21ʰ 23ᵐ 0ˢ, +13° 10′ (1880)
21ʰ 24ᵐ 55ˢ, +13° 20′ (1920)

2ᵐ 3ˢ.3 following and 0′.49 south of *A.G. Leip. I.* 8503 which was used to get the position.

(9.7, 11) (22/9/18; 24-in.)

1918.726	57.8	2.51
.743	57.8	2.60
.759	58.6	2.43
1918.743	58.1	2.51

11221 β 1305 *B.D.* +10° 4622
21ʰ 40ᵐ 7ˢ, +10° 20′ (1880)
21ʰ 42ᵐ 5ˢ, +10° 30′ (1920)

β *G.C.* gives 21ʰ 39ᵐ 9ˢ, +10° 14′ (1880).

(9.3, 10.2, 10.5) (16/10/18; 24-in.)

AB	1918.797	90.8	89.91
BC	1918.792	48.7	0.90
	.797	.6	.89
	1918.795	48.7	0.90

I measure four stars: *D*, *E*, *F*, *G*, each of about the twelfth magnitude as follows:

AD	1918.797	48.6	52.50
AE	.797	67.1	82.82
AF	.797	235.7	44.89
AG	.797	296.4	100.93

J 201 (10, 10.1) (24-in.)
21ʰ 42ᵐ 53ˢ, +10° 6′ (1920) J

About 42ˢ following and 24′ south of *BC* β 1305, 11221.

1918.797	226.7	2 .83

J 165 22ʰ 33ᵐ 56ˢ, +11° 6′ (1920)

This position is given by J. The pair is *A.G. Leip. I.* 9033.

1918.822	135.4

J 208 22ʰ 36ᵐ 57ˢ, +11° 7′ (1880)
22ʰ 38ᵐ 56ˢ, +11° 20′ (1920)

26s.0 preceding and 2′.25 south of *B.D.* +11° 4865. J gives
22h 38m 59s, +11° 19′ (1920)
(9.9, 10.1) (22 10 18; 24-in.)

1918.808	69.5	3.16
1910.814	70.2	3.43 J 1

11957 H 301 ξ *Pegasi*
A.G. Leip. I. 9091
22h 40m 42s, +11° 34′ (1880)
22h 42m 41s, +11° 46′ (1920)
(4.8, 12) (15 10 18; 24-in.)

	°	″
1918.789	106.9	11.62
.792	107.6	.52
1918.791	107.3	11.57

12091 OΣ 183 52 *Pegasi* (24-in.)

1918.810	235.9	0.89
1845.28	180.8	.94 OΣ 2
1897.56	222.6	.95 Hu 7

J 214 *B.D.* +15° 4901
23h 49m 52s, +15° 32′ (1920) J
(11 10 18; 24-in.)

	°	″
1918.786	112.1	3.15
1910.833	109.4	2.33 J 1

Roy. Observatory,
16 November, 1918

(10) *HYGIEA*: PERTURBATIONS BY *JUPITER* AND ELEMENTS,

By A. Estelle Glancy.

In the course of the investigation of the perturbations of the minor planets discovered by James C. Watson, under the direction of Professor A. O. Leuschner, of the University of California, a revision was completed[1] in May 1913 of v. Zeipel's *Angenaeherte Jupiters-Stœrungen fuer die Hecuba-Gruppe.*[2] In connection with this work I prepared detailed directions for the application of v. Zeipel's theory and the use of the revised tables and, for further guidance to the computer, illustrated the same by application to (10) *Hygiea*, the example chosen by v. Zeipel. The problem of correcting the elements of *Hygiea* was not concluded at that time, as indicated by the following statement, (*loc. cit.*, §6)[1]:

"It was originally planned to conclude the example with a least squares solution of the orbit on the basis of the observations used by v. Zeipel for the same purpose, and to test conclusively the relative value of the revised and v. Zeipel's original tables by representing recent observations with both sets of elements and tables.

"In the course of the computation doubt arose regarding the accuracy of some of the observations selected by v. Zeipel, which led to their rejection and the substitution of other observations. This substitution produced an unfavorable distribution of the observed places in the orbit and gave invalid results for the Least Squares solution."

This deficiency has now been met and below is a summary of the procedure and results.

A least square solution has been made, based on the following oppositions, 1849, 52, 55, 64, 67, 73, 79, 82, 84. The observations are those used by v. Zeipel with the exception of two, the accuracy of which was doubtful. These two were replaced by two other dates at the same oppositions. In place of the observations used by v. Zeipel I have substituted the following:

Ber. M. T.	App. α	App. δ	Obs. at	Ref.
h m s	h m s	° ′ ″		
1849 May 21 10 27 04	12 01 30.53	−5 32 45.4	Leipzig	*A. N.* 29, 30
1879 Oct. 6 12 13 54	0 30 37.50	+9 10 48.5	Paris	Ann. Paris 1879
	(Corrected for parallax)			

In neither case is the suspected error large enough to influence the results materially.

The resulting corrections to the elements are small and the new elements are

$$
1850.0 \left\{ \begin{aligned}
\pi_1 &= 231^\circ.0824 \\
\Omega_0 &= 287\ .4578 \\
\omega &= 303\ .6246 \\
i_0 &= 3\ .7917
\end{aligned} \right.
$$

$$
\begin{aligned}
\varphi_1 &= 6\ .3586 \\
c_2 &= 121\ .5316 \\
n_2 &= 636''.86105 \\
&\ 0^\circ.17690585
\end{aligned}
$$

Epoch and Osculation, 1851 Sept. 17.0 Ber. M. T.

The following auxiliary constants have been corrected (*loc. cit.* §1)[1]

$$c_1 = 121^\circ.6100 \qquad \varphi_0 = 220^\circ.674$$

$$\log \frac{1-w}{2} = 9^\circ.67159 \qquad c_0 = 221^\circ.693$$

$$\frac{1-w}{2} \cdot c - c' = 217^\circ.1283$$

The perturbation $[n\delta z]_1$ has been corrected in the first two terms only, namely,

[1] "Tables of the Minor Planets Discovered by James C. Watson," Part II, by A. O. Leuschner, Anna Estelle Glancy, and Sophia H. Levy, "Memoirs of the National Academy of Sciences," Volume XIV, Second Memoir, Washington, 1919, in press.

[2] "Memoires de l'Academie Impériale des Sciences de St. Petersbourg," VIII Série, Classe Physico-Mathématique, Volume XII, No. 11, 1902.

$[n\delta z]_1 = [4.11827] \sin (2\varphi + 73°.0744) +$
$+[3.3124] \sin (4\varphi + 306°.5719) +$ remaining terms.

To be strictly correct the short period terms should be corrected for

$$\Delta\Delta = \Delta\pi = +0°.2856$$

but I am of the opinion that the perturbations would differ by only a few seconds of arc, and in view of the labor involved this correction is neglected.

Before solution the residuals were

Opp.	G in plane	V. Z. $\Delta\lambda \cos\beta$	G ⊥ to plane	V. Z. $\Delta\beta$
	′	′	′	′
1849	+ 4.7	+ 4.6	0.0	+0.8
52	+ 2.5	− 0.5	+0.1	+0.1
55	− 1.4	− 6.2	+0.1	−0.1
61	− 5.1	−14.4	−1.0	+1.1
67	−11.3	−23.1	−1.1	0.0
73	+ 1.3	−15.9	−1.1	+0.4
79	+10.2	− 7.8	−0.6	+0.4
82	+ 4.4	−20.4	+1.0	+0.3
84	− 0.6	−23.5	−1.1	+0.1

Since the inclination of the orbit plane to the ecliptic is only four degrees this comparison is legitimate. The calculations were made to 0°.0001, but the residuals have been abbreviated for comparison. Evidently v. Zeipel's tables represent the position perpendicular to the orbit a little better, but the Berkeley tables are considerably better in the plane.

After solution the residuals are

Opp.	G in plane	V. Z. $\Delta\lambda \cos\beta$	G ⊥ to plane	V. Z. $\Delta\beta$
	′	′	′	′
1849	+4.0	+4.4	−0.5	+0.8
52	−4.0	−4.3	−0.1	+0.1
55	+1.8	+2.0	+0.3	−0.1
61	−0.8	−1.0	−0.2	+1.1
67	−7.5	−6.5	0.0	0.0
73	+1.8	0.0	−0.1	+0.4
79	+7.0	+7.6	0.0	+0.4
82	−2.9	−2.8	0.0	+0.3
84	+0.7	+1.0	0.0	+0.1

No solution was made for $\Delta\beta$, hence the residuals remain unchanged. Evidently there is little choice between the new elements and the Berkeley tables and those of v. Zeipel so far as the oppositions 1849 to 1884 are concerned. It remains to represent later oppositions with both sets of elements and perturbations. For this purpose I have compared an observation for the opposition 1910 and two of my own taken with the 12″ equatorial at the Observatorio Nacional, Córdoba, in the years 1914, 1917.

Ber. M. T.	App. α	App. δ	p_α	p_δ	p_θ	Ref.
	h m s	° ′ ″	s	″		
1910 Feb. 28.5181	10 33 15.76	− 4 12 13.4	. . .	+2.8	Nice	*B. A.* 1910
1914 Feb. 1.6165	2 54 13.52	+19 31 12.6	+0.13	−1.8	Cordoba	*A. J.* 730
Feb. 8.5835	2 58 08.71	+19 39 09.3	+0.11	−1.8	Cordoba	*A. J* 730
Feb. 9.5626	2 58 44.36	+19 40 34.5	+0.10	−1.8	Cordoba	*A. J.* 730
1917 Aug. 23.5606	20 02 18.45	−18 16 27.7	−0.10	−1.0	Cordoba	*A. J.* 732
Aug. 26.5413	20 00 55.31	−18 19 00.8	−0.11	−1.0	Cordoba	*A. J.* 732

The Nice observation was taken with a meridian circle. In the absence of any note, I have computed $p\delta$ on the assumption that the observation needs correction for parallax.

The following residuals were computed.

(O - C)

Date	G Before $\Delta\alpha\cos\delta$	G Before $\Delta\delta$	G After $\Delta\alpha\cos\delta$	G After $\Delta\delta$	V. Z. After $\Delta\alpha\cos\delta$	V. Z. After $\Delta\delta$
	″	″	″	″	″	″
1910 Feb. 28	+ 7.6	−1.2	−0.4	+0.5	+ 7.9	−3.8
1914 Feb. 1	+10.1	+1.9				
Feb. 8	+ 9.7	+1.8				
Feb. 9	+ 9.5	+1.8	+2.5	+0.2	+ 8.6	+1.1
1917 Aug. 23			+9.2	+3.1	. . .	. . . .
Aug. 26			+9.4	+3.2	+18.7	+6.3

The representation of the observation Feb. 28, 1910 is as good before solution with uncorrected elements and the Berkeley tables of perturbations as it is with v. Zeipel's corrected elements and perturbations.

After solution it is highly satisfactory. This is interesting because the original solution referred to above, which was discarded as invalid, gave the abnormal residuals, (O – C),

$$\Delta\alpha \cos\delta \qquad \Delta\delta$$
$$+14'.5 \qquad -20'.2$$

This rejected solution was based on the oppositions 1849, 53, 55, 65, 67, 73, 79, 83, a distribution in the orbit such that

$$v = 140^\circ \text{ to } v = 254^\circ$$

was entirely unrepresented. The corrections to the elements were larger than had been expected in view of the excellence of the original osculating elements, and the foregoing table now justifies the assertion that the solution gave fictitious corrections.

One more factor may have entered into the fictitious solution. The statement is made by v. ZEIPEL that the long period terms of the fourth degree in $n\delta z$ may sometimes reach the magnitude 3'. It is not impossible that the oppositions chosen were unfortunate in this respect.

The observations 1914, 1917 were also satisfactorily represented and (O – C) is smaller in the G columns than in the v, Z columns.

It would be better for practical purposes in the future if the epoch of the perturbations and the elements were brought up to date, for the interval since the epoch has already reached sixty-six years and the long period terms in the perturbations are considerable. If this were done I think an improvement would result and probably the somewhat large discrepancies in the residuals for neighboring dates would disappear. A second least square solution might also be made, using more recent observations. But these extensions would involve a considerable amount of laborious calculations.

All the more important parts of the computations have been repeated and numerous independent checks have been applied and it is believed that no significant errors remain in the results.

I am pleased to acknowledge the kindness of Director PERRINE in allowing me the time to bring this work to a conclusion.

Observatorio Nacional, Cordoba, Feb. 5, 1918.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1918	Time	New Grs.	Total Grs.	Total Spots	Fac Grs.	Def.	1918	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs	Def	1918	Time	New Grs	Total Grs	Total Spots	Fac. Grs.	Def
July 1	12	3	8	21	1	fair	July 25	7	1	6	127	3	fair	Aug 20	7	2	8	44	3	fair
2	7	–	9	22	1	fair	26	11	1	7	98	3	fair	21	7	1	9	50	3	fair
3	7	2	9	41	2	fair	27	6	3	10	104	3	fair	22	8	1	10	46	3	fair
4	6		5	71	3	fair	28	6	0	10	98	2	fair	23	4	–	6	59	4	fair
5	6	–	5	70	3	fair	29	6	0	5	50	1	poor	24	7		6	49	3	fair
6	7		5	72	3	fair	30	6	0	4	66	1	poor	25	9	–	4	27	2	poor
7	7	–	5	66	2	fair	Aug. 1	7	1	4	30	1	poor	26	7		4	50	2	fair
8	7	–	4	27	1	fair	2	7	1	5	68	3	fair	27	7	–	4	25	2	poor
9	7	2	6	27	1	fair	3	7	–	4	60	2	fair	28	7	2	6	29	3	fair
10	7	–	7	26	2	fair	4	6	1	6	100	2	fair	29	10	2	4	24	2	fair
11	7		7	27	3	fair	5	6	–	5	37	2	fair	30	8		4	14	3	fair
12	7	–	7	36	3	fair	6	6		4	18	2	fair	31	8		4	10	1	fair
13	10		6	10		poor	7	6	2	6	37	2	fair	Sept. 1	8	–	3	8	2	fair
14	3	–	6	18	1	fair	8	6	1	7	19	1	fair	2	7	1	3	6	2	fair
15	7	1	6	25	2	fair	9	7	–	6	14	1	fair	3	7	1	1	7	2	fair
16	7	–	4	30	3	fair	11	12	–	4	17	2	fair	4	7		2	1	1	fair
17	3	1	4	20	2	fair	12	7	–	4	16	2	fair	5	7	–	1	1	1	fair
18	7	–	3	20	3	fair	13	7	1	5	35	3	fair	6	7	2	4	14	1	fair
19	7	2	5	24	3	fair	14	7	1	6	40	3	fair	7	12	1	5	19	1	fair
20	7	–	5	37	2	fair	15	6	–	4	66	3	fair	9	7		4	13	1	fair
21	7	–	5	52	3	fair	16	4	–	3	65	1	fair	10	7	–	4	18	4	fair
22	7	1	5	54	4	fair	17	3	1	3	68	2	fair	11	9	–	4	14	3	fair
23	7	–	4	79	3	fair	18	7	2	5	58	3	fair	12	8	–	4	28	2	fair
24	7	2	6	138	3	fair	19	7	1	6	70	3	fair	13	8		3	54	1	fair

SUNSPOT OBSERVATIONS (*Continued.*)

1918	Time	New Grs	Total Grs	Total Spots	Fac Grs	Def
Sept. 14	8	3	6	38	2	fair
15	8	1	4	32	3	fair
16	8		4	40	2	fair
17	8	1	3	38	3	fair
18	5	2	5	20	3	fair
19	6	2	7	20	3	fair
21	8	1	4	20		fair
22	8	1	5	39	2	fair
23	8	–	4	32	2	fair
24	12		4	37	1	fair
25	8		4	21	1	fair
26	8	1	5	21	1	fair
27	8	1	6	21	3	fair
28	6	1	7	52	3	fair
29	8		7	56	3	fair
30	8	–	5	56	2	fair
Oct. 1	4		3	38	1	fair
2	4	2	1	50	2	fair
3	12		4	14	2	poor
4	5	1	4	18	3	poor
5	8		3	9	2	poor
6	10	1	3	6	2	fair
7	4	–	3	10	1	fair
8	8	1	4	39	2	fair
9	8	1	5	23	2	fair
10	8		2	24	2	fair
11	8	1	3	23	2	fair
12	5	1	3	24	3	fair
13	8		2	13	2	fair
14	10	–	2	16	2	fair
15	2	2	1	34	3	fair
16	9	1	5	32	4	fair
17	9		5	36	4	fair
18	8	2	7	36	3	fair

1918	Time	New Grs	Total Grs	Total Spots	Fac Grs	Def.
Oct. 19	5	2	9	55	2	fair
20	8	–	7	48	3	fair
21	8	–	4	32	2	fair
22	8	1	6	56	2	fair
23	9	2	8	48	2	fair
24	8	1	6	33	2	fair
25	8	–	6	36	3	fair
26	4	–	4	6		poor
27	2	–	6	21	2	fair
28	12	2	7	24	3	fair
29	9		7	15	4	fair
30	8		6	11	1	poor
31	8		5	16	2	poor
Nov. 1	8		5	15	1	poor
2	8		5	12	1	fair
3	8	–	4	6	2	fair
4	8		2	2		poor
5	9	–	3	8	1	fair
6	8		2	3	2	fair
7	8		2	9	2	fair
8	9	2	3	12	3	fair
9	2		1	3		poor
10	8	–	2	11	2	fair
11	3	1	3	10	2	fair
12	8		2	12	2	fair
13	4	–	2	6	2	poor
14	9	1	3	12	3	poor
15	8	2	5	28	3	fair
16	8	4	9	31	4	fair
18	12	2	11	74	3	fair
19	8	–	11	70	3	fair
20	4		5	14	–	poor
21	8	1	11	68	3	fair
22	8	–	10	34	5	fair

1918	Time	New Grs	Total Grs.	Total Spots	Fac Grs	Def
Nov. 23	2		7	30	3	fair
24	8	–	7	21	2	fair
25	8		5	22	2	fair
26	8	–	5	21	4	fair
27	8	–	3	30	4	fair
29	8	–	3	20	3	poor
30	8		3	22	2	poor
Dec. 1	8		2	16	1	poor
2	8	2	4	15	3	poor
3	8	–	2	4	2	poor
4	8	–	2	5	1	fair
5	8	–	2	8	1	fair
6	8	1	3	8	3	fair
7	8		1	1		poor
8	9	1	4	12	3	fair
9	8	–	4	15	4	fair
10	10		3	5	2	poor
12	9	1	3	10	2	fair
13	10	–	2	2		poor
17	8	3	4	5	2	poor
18	4	1	5	21	3	fair
19	8		4	15	3	fair
20	8	2	6	25	4	fair
21	8	–	4	25	2	fair
23	8	1	5	38	2	fair
25	11	1	6	53	2	fair
26	11	–	6	15	2	fair
27	8	1	6	45	2	fair
28	10	–	6	19	2	fair
29	3	–	6	25	3	fair
30	8	–	3	15	2	fair
31	8	–	2	6	1	fair

DEFINITIVE ORBIT OF COMET 1786 II, ERRATA,

By MARGARETTA PALMER.

By a typographical error in *A. J.* 744, pp. 192–194, the lines indicating the grouping of observations to form the seven normal places were omitted. Such horizontal lines should have been drawn below the following:

No.	Berlin Mean Time	Place
18	Aug. 16.44807	Paris
41	Aug. 25.41565	Chislehurst
71	Sept. 2.40907	Chislehurst
95	Sept. 12.34034	Milan (C)
121	Sept. 23.33720	Saron
136	Oct. 13.35352	Milan (C)

OBSERVATIONS OF VARIABLE STARS.

By WILLIAM DOBERCK.

(Continued from A. J., 723.)

RS Andromedæ: The magnitudes of the comparison stars have been determined in steps converted into magnitudes by aid of *H. C.* photometric magnitudes: *a* (*A.S.V.6*) 7.74, *b* (7) 7.80, *c* (10) 8.18, *d* (22) 8.78, *e*(20)8.96. *a* and *b* belong to different spectral classes, which increases the probable error of their difference observed in steps. *d* appears to be variable, but this is not certain as it is unfavorably situated for comparison with the other stars. The variable star is red. The value of the step is 0.112 mag. The following maxima (7.8) are indicated: 2420335?, 0730?, 1120?, 1645, and 1915, and the minima (8.9) 1580, and 1860. The period is very irregular. Its average length is about 400 days. The minima preceded the maxima by about 80 days.

0349	*a* 2 *v* 1 *c*	8.04	0801	*c* 3 *v* 4 *e*	8.51	1578	*v* 1 *e*	8.85	1787	*c* 1 *v* 3 *d*	8.33
0358	*v* = *e*	8.18	0887	*c* 3 *v* 4 *e*	8.51	1596	*c* 3 *v* 2 *e*	8.65	1812	*c* 2 *v* 3 *d*	8.42
0371	*a* 3 *v* 1 *c*	8.07	0899	*c* 2 *v* 4 *e*	8.44	1607	*c* 3 *v* 1 *e*	8.51	1826	*v* = *d*	8.78
0382	*a* 3 *v* 1 *c*	8.07	1048	*b* 3½ *v* 1½ *c*	8.07	1615	*c* 3 *v* 1 *e*	8.51	1830	*d* 1½ *v* 4 *e*	8.83
0396	*c* 1 *v* 3 *d*	8.33	1070	*c* 4 *v* 3 *d*	8.53	1626	*b* 2 *v* 1 *c*	8.05	1843	*d* 3 *v* 1 *e*	8.92
0438	*c* 3 *v* 3 *d*	8.48	1120	*v* = *a*	7.74	1633	*b* 1 *v* 2½ *c*	7.91	1845	*d* 1 *v* = *e*	8.92
0465	*a* 5 *v* 5 *d*	8.26	1168	*a* 3 *v* 1 *c*	8.09	1640	*b* 1 *v* 2 *c*	7.93	1860	*e* ½ *v*	9.03
0482	*c* 1½ *c*	8.35	1188	*a* 2 *v* 1½ *c*	8.00	1643	*a* 3½ *v* 1 *b*	7.78	1867	*v* 1½ *d* = *e*	8.96
0507	*v* = *a*	7.74	1239	*a* 3 *v* 2 *c*	8.04	1661	*b* 2 *v* 3 *c*	7.95	1875	*v* 2½ *e*	8.71
0538	*c* 3 *v* 7 *d*	8.36	1507	*a* 4 *v* 1 *c*	8.09	1675	*b* 2 *v* 2 *c*	7.99	1889	*c* 1½ *v* 5 *e*	8.36
0691	*a* 3 *v* 2 *c*	8.00	1521	*c* 4½ *v* 2 *e*	8.72	1683	*v* = *c*	8.18	1900	*d* 1 *v*	7.85
0722	*v* 2 *a*	7.52	1522	*c* 5 *v* 3 *e*	8.66	1722	*b* 3 *v* 1 *c*	8.09	1905	*b* 3 *v* 3 *c*	7.99
0736	*v* = *a*	7.74	1537	*c* 3 *v* 4½ *e*	8.49	1743	*c* 3 *v* 3 *d*	8.48	1907	*b* 2 *v* 3 *c*	7.95
0751	*b* 1 *v* 1 *a*	7.77	1549	*c* 3 *v* 5 *e*	8.47	1746	*c* 1½ *v*	8.35	1919	*b* 1 *v*	7.91
0779	*c* 3 *v* 5 *e*	8.47	1568	*v* 2 *e*	8.74	1758	*c* 2 *v* 3 *d*	8.42	1920	*a* 2 *v*	7.96
0785	*c* 3 *v* 3 *e*	8.57	1576	*c* 4 *v* 3 *e*	8.63	1777	*c* 2 *v* 3 *d*	8.42	1925	*b* ½ *v* 4 *c*	7.84

The observations are being continued.

RS Cygni: The magnitudes of the comparison stars have been determined in steps. The value of a step is 0.14 mag. By aid of the *H. C.* photometric magnitudes they were expressed in magnitudes: *a*(*A.S.V.* 7.) 7.11, *b*(4)7.36, *c*(9)7.71, *d*(10)7.96, *e*(14)8.03, *f*(16)8.37, (*g*15)8.46, *h*(25)9.16. The star is highly colored and the variation appears to be subject to irregularities. The elements have been determined from the observations given below and are very rough. The maximum (7.2) occurred on 2421304, the minimum (8.3) on 2421573. The period appears to be about 416 days.

0344	*v* = *g*	8.5	0663	*v* 3 *d*	7.5	1113	*v* = ½ (*d* + [illegible])	8.0	1511	*d* 1 *v* 3 *f*	8.1
0347	*v* = *f*	8.4	0691	*b* 2½ *v* 3 *e*	7.7	1125	*d* 2 *v* 2 *e*	8.0	1522	*d* 4 *v* 3 *f*	8.2
0349	*v* = *e*	8.0	0711	*v* = *f*	8.4	1126	*b* 3 *v* 2 *e*	7.8	1537	*d* 3 *v* 3 *f*	8.2
0355	*v* = *e*	8.0	0725	*b* 5 *v* 4 *f*	7.9	1134	*e* 3 *v* 2 *f*	8.2	1540	*v* 1½ *f*	8.2
0362	*b* 5 *v* 5 *f*	7.9	0736	*d* 1 *v* 3 *f*	8.1	1156	*v* 2 *e*	7.8	1558	*v* = *e*	8.0
0374	*b* 1 *v* 3 *e*	7.5	0750	*d* 2 *v*	8.2	1170	*d* 2 *v* 1 *e*	8.0	1568	*d* 3 *v* 3 *f*	8.2
0381	*b* 3 *v* 1 *d*	7.8	0774	*b* 3 *v* 1 *d*	7.8	1190	*b* 2 *v* 1 *d*	7.8	1727	*v* 1 *b*	7.2
0395	*v* = *d*	8.0	0784	*b* 2 *v*	7.6	1193	*a* 3 *v* 3 *f*	7.7	1732	*v* ½ *b*	7.3
0399	*b* 2½ *v* 5 *e*	7.6	0800	*b* = *v*	7.4	1202	*b* 3 *v* 3 *e*	7.7	1744	*v* 2 *b*	7.1
0434	*b* 1 *v*	7.5	0887	*b* 1 *v* 3 *c*	7.5	1357	*v* 2 *b*	7.1	1760	*b* 1 *v*	7.5
0464	*v* = *b*	7.4	0901	*b* 1 *v*	7.5	1384	*v* 1½ *b*	7.1	1777	*a* 1 *v* 2 *b*	7.2
0475	*v* 2½ *b*	7.0	1040	*b* 3 *v* 3 *e*	7.7	1391	*a* 1 *v* 4 *b*	7.2	1787	*v* = *b*	7.4
0488	*b* 3 *v*	7.8	1049	*v* = *c*	7.7	1435	*v* 2 *b*	7.1	1820	*b* 2 *v*	7.6
0506	*b* 1 *v*	7.5	1067	*c* 2 *v*	8.0	1459	*b* 2 *v*	7.6	1828	*b* 2 *v*	7.6
0534	*b* 1½ *v* 2 *c*	7.5	1078	*b* 2 *v* 3 *c*	7.5	1473	*b* 2 *v*	7.6	1843	*b* 1 *v*	7.5
0646	*b* 2 *v* 3 *d*	7.6	1084	*a* 4 *v* 5 *f*	7.7	1502	*e* 1 *v*	8.2	1864	*b* 2 *v*	7.6
									1874	*b* 2 *v* 2 *e*	7.7

X Lyræ. The magnitudes of the comparison stars were determined in steps and converted into magnitudes by comparison with 5 photometric *H. C. O.* magnitudes: *a*(*A.S.V.* 11)7.39, *b*(15)8.09, *c*(18)8.49, *d*8.67, *e*(32)8.89, *f*(31)8.91, *g*9.07, *h*(38)9.25, *k*(40)9.44. The identity of *d* has been lost. *g* is $19^h\ 7^m\ 50^s$, 26° 29′ (1900). The value of a step is 0.10 mag.

During the past 4 years there has not been any more variation in the brightness of this star than in other stars, that are not considered variable. From 0342 to 0485 the magnitude was 8.93 from 11 observations. 0653 — 0801 9.09 (12). 0979 — 1206 9.03 (12). 1348 — 1565 8.95 (11). 1732 — 1880 8.82 (10). The probable error of one comparison is exactly a step, and that is made up of the error of observation and change of brightness of the star.

S Vulpeculæ. The magnitudes of the comparison stars were determined in steps and converted into magnitudes by comparison with photometric *H. C. O.* magnitudes: a (*A.S.V.* 9) 7.81, *b*(10)7.87, *c*(12)8.19, *d*(14)8.41, *e*(29)8.80, *f*(28)8.85, *g*(35)9.01, *h*(38)9.06, *k*(50)9.19, *l*(45)9.25, *m*(52)9.70. The value of a step is 0.09 mag.

The maximum (8.60) occurred about 2421432, and the minimum (9.01) about 2421470. The minimum is better defined than the maximum. The period is 67.58 days.

Chandler in his third catalogue gives the formula for the maximum: 2402239 + 67.5*E*. (*M* − *m* 26.5 days). This formula gives the epoch of maximum at present only 3 weeks too early, and the minimum only 5 weeks too early.

0344	*v* 2 *c*	8.62	0679	*c* 5 *v* 3 *c*	8.57	1113	*v* = *c*	8.80	1566	*d* 4 *v* 3 *c*	8.63
0357	*v* = *c*	.80	0696	*c* 1 *v*	.89	1133	*v* = *h*	9.06	1746	*e* 2 *v* 2 *k*	9.00
0370	*c* 1 *v* 3 *g*	.85	0708	*c* 5 *v* 1 *f*	.74	1158	*v* 3 *e*	8.53	1760	*v* 1 *c*	8.71
0375	*e* 2 *v*	.98	0722	*e* 3 *v* 3 *l*	9.02	1201	*e* 1½ *v* 3 *k*	.93	1767	*v* 2 *f*	.67
0381	*g* 2 *v* 3 *l*	9.11	0729	*e* 4 *v* 3 *l*	.06	1348	*v* 2 *f*	.67	1777	*v* 3 *f*	.58
0387	*c* 1 *v* 3 *l*	8.91	0746	*e* 1 *v* 3 *g*	8.85	1384	*v* 2 *c*	.62	1784	*v* 3 *c*	.53
0430	*v* 2 *c*	.62	0753	*v* 2 *g*	.83	1388	*f* 2 *v* 2 *c*	.82	1815	*e* 3 *v* ½ *g*	.98
0464	*d* 5 *v* 2½ *h*	.84	0770	*v* 1 *c*	.71	1429	*v* 2 *e*	.62	1824	*e* 1 *v*	.89
0475	*v* 3 *c*	.53	0781	*c* 1 *v* 3 *k*	.90	1457	*c* 2 *v* 4 *g*	.87	1838	*v* 2 *c*	.62
0488	*c* 5 *v* 4 *c*	.53	0799	*e* 2 *v* 3 *g*	.88	1473	*v* 1 *c*	.71	1844	*v* 1 *c*	.71
0506	*v* = *c*	.80	1040	*f* 2 *v* 3 *c*	.82	1504	*v* 2 *c*	.62	1864	*v* 1½ *e*	.67
0653	*c* 1 *v* 3 *l*	.91	1070	*c* 1 *v* 3 *k*	.90	1511	*d* 2 *v* 3 *f*	.59	1874	*e* 2 *v* 1 *f*	.84
0664	*c* 1 *v* 3 *k*	.90	1111	*v* 1½ *f*	.72	1539	*c* 5 *v* 3 *k*	9.04	1879	*f* 2 *v* 1 *l*	9.12

Nova Aquilæ (1918): The comparison stars were: *a* α*Aquilæ*, *b* α*Ursæ Majoris*, *c*. α*Ophiuchi*, *d* η*Ophiuchi*, *e* γ*Aquilæ*, *f* β*Ophiuchi*, *g* η*Serpentis*, *h* δ*Aquilæ*, *k* β*Scuti*, *l* θ*Serpentis*, *m* ζ*Aquilæ*, *n* λ*Aquilæ*. The *R. H. P.* magnitudes were used except in case of *l*(4.11) which has been determined from 5 comparisons with *h* and *m*. The month, the date, and G. M. T. are shown in the following table:

VI	13^d	9^h	40^m	*v* 1½ *a*	0.7
	15	11	4	*a* 4½ *v* 3 *e*	1.6
	15	11	32	*b* 1 *v*	2.1
	16	11	7	*b* 1 *v* 3 *e*	2.0
	22	12	13	*e* 3 *v* 2 *f*	2.6
	29	11	3	*g* 2 *v* = *h*	3.6
VII	2	11	44	*e* 4 *v* 2 *g*	3.2
	3	12	30	*f* 2 *v* 2 *g*	3.2
	8	11	19	*h* 1 *v* 1 *g*	3.4
	9	10	59	*v* = *h*	3.4
	10	10	55	*h* 2 *v* 3 *l*	3.7
	12	10	48	*h* 3½ *v* 1 *l*	4.0
	18	12	12	*h* 2 *v* 3 *l*	3.7
	29	9	50	*h* 3 *v* 2 *l*	3.8
VIII	9	11	11	*h* 3½ *v* 1 *l*	4.0
	13	10	14	*l* 2 *v* 3 *m*	4.5
	14	11	3	*l* 3 *v* 4 *m*	4.5
	24	10	5	*k* 3 *v* 3 *m*	4.8
IX	1	9	18	*v* 1½ *m*	4.8
	2	10	50	*v* 1 *m*	4.9
	6	9	48	*v* 1 *m*	4.9
	7	10	22	*l* 3 *v* 4 *m*	4.5
	8	9	0	*l* 3 *v* 4 *m*	4.5
	10	8	29	*l* 4 *v* 3 *m*	4.6
	25	7	20	*v* 2 *m*	4.7
	28	6	46	*m* 2 *v* 5 *n*	5.2
X	3	7	44	*m* 1½ *v*	5.3
	6	8	3	*v* = *m*	5.0
	8	8	20	*m* 1 *v*	5.2

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THE LIMITING PARALLELS OF LATITUDE FOR OCCULTATIONS OF FIXED STARS BY THE *MOON*.

By W. AUHAGEN.

It is my opinion, based upon practical experience, that the determination of these limiting parallels of latitude should take into account the oblateness and revolution of the *Earth* rather than neglect both factors as is usually done, apparently for no other reason than that the formulæ thus obtained are extremely simple. The rigorous solution of the problem, as attempted in the following pages, naturally cannot lead to such simple results, yet it must be admitted that by arranging suitable tables (which is very well possible) the numerical work may be performed rapidly. It is well also to convince oneself, how far the assumption of a purely spherical *Earth* without revolution about its polar axis deviates from the truth as regards these limiting parallels, whereby the investigation of the true status gains from a mathematical standpoint.

According to BESSEL'S "Analyse du Finsternipe" all eclipse problems are reducible to their simplest form by adopting a system of coördinate axes, origin at the center of the *Earth*, in which a line parallel to the shadow axis is the axis of z, while the $y\,z$ plane passes through the polar axis. The coördinates of a place of observation then are:

$$
\begin{aligned}
&\xi = \rho \cos\varphi' \sin(\mu - a)\\
(1)\quad &\eta = \rho\,(\sin\varphi' \cos\delta - \cos\varphi' \sin\delta \cos(\mu - a))\\
&\zeta = \rho\,(\sin\varphi' \sin\delta + \cos\varphi' \cos\delta \cdot \cos(\mu - a))
\end{aligned}
$$

We are here concerned with the places which are situated along the northern and southern limiting shadow curves which the cylindrical shadow cast by the *Moon* under the stellar light intercepts on the spheroidal surface of the *Earth* while passing over the latter. At all these places but a simple contact may be observed, the *Moon* passing either wholly south of the star (northern limit) or wholly north of the star (southern limit) and the distance of these places from the shadow axis has the minimum value equal to k or the radius of the *Moon* expressed in units of the equatoreal radius of the *Earth*. Let this distance be $\Delta = \sqrt{(x - \xi)^2 + (y - \eta)^2}$, then

$$\Delta \cdot \frac{d\Delta}{d\tau} = (x - \xi)(x' - \xi') + (y - \eta)(y' - \eta') = 0$$

where $x = x_0 + x'\,\tau$, $y = y_0 + \gamma_1\,\tau$ are the coordinates of the *Moon* for the time $T = T_0 + \tau$, x', y', ξ', η' the variations of these coördinates and those of the place of observation respectively in a unit of time, we get

$$
\begin{aligned}
\tau &= -\nu[(x_0 - \xi)(x' - \xi') + (y_0 - \eta)(y' - \eta')]\,;\\
x - \xi &= \sigma\,(y' - \eta')\,;\; y - \eta = \sigma\,(x' - \xi')
\end{aligned}
$$

where $\nu = 1 : x'(x' - \xi') + y'(y' - \eta')$

and $\sigma = \nu[(x_0 - \xi)\,y' - (y_0 - \eta)\,x']$

Putting

$$
\begin{aligned}
x' &= n \sin N \qquad & x' - \xi' &= n' \sin N' \qquad (2)\\
y' &= n \cos N \qquad & y' - \eta' &= n' \cos N'
\end{aligned}
$$

we evidently get the following condition for the points along the northern or southern shadow curve, according as the upper or lower sign is taken, *viz.:*

$$
\begin{aligned}
-\xi \cos N + \eta \sin N = &- x_0 \cos N + y_0 \sin N\\
&\pm k \cos(N - N') \qquad (3)
\end{aligned}
$$

The usual neglect of the factor of $\pm k$, *viz.:* $\cos(N - N')$, is evidently equivalent to neglecting the apparent or relative motion $x' - \xi'$ and $y' - \eta'$.

In the plane $x\,y$ we assume another system of rectangular axes b, c, so that

$$b = \xi \sin N + \eta \cos N\,;\; c = -\xi \cos N + \eta \sin N \qquad (4)$$

Let h the geocentric angular distance of the place of

observation from the star, H its position angle at the star with regard to the declination circle of the latter, then

$$\begin{aligned} b &= \rho \sin h \cos (N - H) = \rho \sin \mu \cos \nu \\ (5) \qquad c &= \rho \sin h \sin (N - H) = \rho \cos \mu \\ \zeta &= \rho \cos h \qquad\qquad\quad\;\; = \rho \sin \mu \sin \nu \end{aligned}$$

where μ the angular distance of the place of observation from the point where the axis of c meets the sphere, and ν the angle which the plane of the great circle, along which this distance is measured, makes with the plane $x\, y$. Comparing (4) and (5) with (3) we get:

$$\begin{aligned} c = \rho \cos \mu &= -x_0 \cos N + y_0 \sin N \pm k \cos (N - N') \\ (6) \qquad &= c_0 \pm k \cos (N - N') \end{aligned}$$

Since we are concerned with the latitudes of the places along the limiting shadow curves, we derive from (1)

$$\rho \sin \varphi' = \sqrt{1 - e^2} \cdot \sin \varphi_1 = \eta \cdot \cos \delta + \zeta \cdot \sin \delta$$

where φ_1 is the latitude of the place on the sphere concentrically circumscribes about the spheroid where a line parallel to the polar axis of the latter meets the sphere if drawn from the point ξ, $\eta\, \zeta$ on the spheroid. This is equivalent to assuming $\rho \cos \varphi' = \cos \varphi_1$. We have from (4) and (5)

$$\eta = \rho \sin \mu \cos \nu \cdot \cos N - \rho \cos \mu \sin N$$

Since $c = \rho \cos \mu$ we have

$$\rho \sin \mu = \sqrt{\rho^2 - \rho^2 \cos^2 \mu} = \sqrt{\rho^2 - c^2}\,;$$

but $\rho^2 = 1 - e^2 \sin^2 \varphi_1$ hence

$$\kappa = \rho \sin \mu = \sqrt{1 - c^2 - e^2 \sin^2 \varphi_1} \qquad (7)$$

Let

$$\begin{aligned} \sin \delta = \cos \beta \sin \lambda,\ \cos \delta \cos N &= \cos \beta \cos \lambda, \\ \cos \delta \sin N &= \sin \beta \qquad (8) \end{aligned}$$

and we have, substituting the values of η and ζ in terms of $\rho\ \mu\ \nu$:

$$\sqrt{1 - e^2} \cdot \sin \varphi_1 = \sqrt{1 - c^2 - e^2 \sin \varphi_1} \cdot \cos \beta \cos (\nu - \lambda) - c \cdot \sin \beta \qquad (9)$$

hence:

$$\sin \varphi_1 = \frac{c \sqrt{1 - e^2} \cdot \sin \beta \pm \cos \beta \cos (\nu - \lambda) \sqrt{(1 - c^2)\,(1 - c^2 + e^2 \cos^2 \beta \cos^2 (\nu - \lambda) - c^2 e^2 \sin^2 \beta}}{1 - c^2 + c^2 \cos^2 \beta \cos^2 (\nu - \lambda)} \qquad (9a)$$

Since subsequently the *special* value of $\sin \varphi_1$ is wanted for $\nu = \lambda$ or $\nu = \lambda \pm 180°$, we state it here, *viz.:*

For $\nu = \lambda,\ \lambda \pm 180$

$$(10)\quad \sin \varphi_1 = \frac{c \sqrt{1 - e^2} \cdot \sin \beta \pm \cos \beta \sqrt{1 - c^2 - e^2 \sin^2 \beta}}{1 - e^2 \sin^2 \beta}$$

It is to be noted that $\sin \varphi_1$ is here made to depend upon the two variables c and ν; but c depending upon $\cos (N - N')$ varies with N' or ξ' and η', because N must be considered as immediately available from the motion of the *Moon*, at least can always be obtained by successive approximation if extreme accuracy be required; we have to deal with c as a datum of the problem the value of which we approach by degrees. From (1) we now have

$$\xi' = m'(-\eta \sin \delta + \zeta \cos \delta), \qquad \eta' = m' \zeta \sin \delta$$

or

$$\begin{aligned} \xi' &= m'[\kappa (\cos \delta \sin \nu - \sin \delta \cos N \cdot \cos \nu) \\ (11) \qquad &\qquad - c \cdot \sin \delta \sin N] \end{aligned}$$

$$\eta' = m'[\kappa \cdot \sin \delta \cdot \sin N \cos \nu - c \cdot \sin \delta \cdot \cos N]$$

where m' the change of the sidereal time in the unit of time (one hour of mean time, say). It is plainly visible, that although according to (5) c does not depend upon ν, yet this variable is involved in c and $d\,c : d\,\nu$ must be taken care of in the expression of

$$\frac{d \sin \varphi_1}{d\, \nu} = 0$$

which is required to determine the maxima and minima of φ_1. Putting, for short,

$$\cos \beta : \sqrt{1 - e^2} = g_1\,, \text{ and } \quad \sin \beta : \sqrt{1 - e^2} = g_2$$

and also replacing $\sqrt{1 - c^2 - e^2 \sin^2 \varphi_1}$ by its symbol κ whenever it reappears after being operated upon, we get from (9), (9a being unmanageable)

$$\begin{aligned} \frac{d \sin \varphi_1}{d\, \nu} = &- g_1 \cos (\nu - \lambda) \frac{e^2 \sin \varphi_1}{\kappa} \cdot \frac{d \sin \varphi_1}{d\, \nu} - g_1 \cdot \kappa \cdot \sin (\nu - \lambda) \\ &- \frac{1}{\kappa} (g_1 \cos (\nu - \lambda) - g_2\ \ \kappa) \frac{d\, c}{d\, \nu} \end{aligned}$$

whence solving for $d \sin \varphi_1 : d\nu$, we get

$$\frac{d \sin \varphi_1}{d\nu} = \frac{1}{\kappa + g_1 e^2 \sin \varphi_1 \cos(\nu - \lambda)} \left[- g_1 \kappa^2 \sin (\nu - \lambda) - (g_1 \cos(\nu - \lambda) - g_1 \cdot \kappa) \frac{dc}{d\nu} \right]$$

but

$$\frac{dc}{d\nu} = \frac{dc}{dN'} \frac{dN'}{d\nu} = \pm k \sin (N - N') \frac{dN'}{d\nu} \tag{12}$$

hence, putting for short

$$l = - \frac{g_1}{\kappa + g_1 e^2 \sin \varphi_1 \cos(\nu - \lambda)}, \quad m = - \frac{g_1 \cos(\nu - \lambda) - g_1 \nu_1}{\kappa + g_1 e^2 \sin \varphi_1 \cos(\nu - \lambda)}, \quad \pm k = k$$

we get

(13)

$$\frac{d \sin \varphi_1}{d\nu} = l \kappa^2 \sin(\nu - \lambda) + k \cdot m \cdot \sin(N - N') \frac{dN'}{d\nu}$$

We must now develop $dN' : d\nu$. We have at once

$$\frac{n' \, dN'}{d\nu} = - \cos N' \frac{d\xi'}{d\nu} + \sin N' \cdot \frac{d\eta'}{d\nu} \tag{14}$$

From (11) we obtain:

$$\begin{aligned} \frac{d\xi'}{d\nu} &= m' \left[p \cdot \kappa + p_1 \frac{d\nu_1}{d\nu} - \sin\delta \sin N \cdot k \sin(N - N') \cdot \frac{dN'}{d\nu} \right] \\ \frac{d\eta'}{d\nu} &= m' \left[q \cdot \kappa + q_1 \frac{d\nu_1}{d\nu} - \sin\delta \cdot \cos N \cdot k \cdot \sin(N - N') \frac{dN'}{d\nu} \right] \end{aligned} \tag{15}$$

where

$$\begin{aligned} p &= \cos\delta \cos\nu + \sin\delta \cos N \cdot \sin\nu, & q &= - \sin\delta \sin N \sin\nu \\ p_1 &= \cos\delta \sin\nu - \sin\delta \cos N \cos\nu, & q_1 &= \sin\delta \sin N \cos\nu \end{aligned} \tag{16}$$

But

$$\frac{d\kappa_1}{d\nu} = - \frac{e^2 \sin\varphi_1}{\kappa} \cdot \frac{d \sin\varphi_1}{d\nu} - \frac{c}{\kappa} \cdot k \sin(N - N') \cdot \frac{dN'}{d\nu}$$

in which we have to substitute the value of $d \sin \varphi_1 : d\nu$ from (13); then we must substitute $d\kappa : d\nu$ in (15) and with the values obtained for $d\xi' : d\nu$ and $d\eta' : d\nu$ we have to solve (14) for $dN' : d\nu$. However, since the resulting expression contains terms in $\sin^2 (N - N')$ and $c^2 \sin(N - N')$ which are very small because $\sin(N - N')$ is small (assumably of the first order of magnitude) they are here neglected, as the nature of the problem does not strictly warrant their consideration. Thus we get

$$\frac{dN'}{d\nu} = - \frac{\kappa^2 \; m^1 (p \cos N' - q \sin N')}{\kappa \cdot n' - c\, m' k \sin(N - N') (p_1 \cos N' - q_1 \sin N')} \tag{17}$$

and with this from (13) equated to zero, after the restoration of the values of l and m, we get

$$\sin(\nu - \lambda) = \frac{m' k \sin(N - N') \cdot (p \cos N' - q \sin N') (\cos(\nu - \lambda) - \kappa \operatorname{tg} \beta)}{\kappa n' - c\, m' k \sin(N - N') (p_1 \cos N' - q_1 \sin N')} \tag{18}$$

This expression is rigorous as far as the first power of $\sin(N - N')$ is concerned which, in practice, is all that is necessary. But since the terms $p\, q\, p_1\, q_1$ are multiplied in the small factor $\sin(N - N')$ it will be not only convenient but still within the limits of accuracy to assume in *these* terms $N' = N$; then, according to (8)

$$\cos\delta \cos N' = \cos\beta \cos\lambda, \quad \sin\delta = \cos\beta \sin\lambda$$

hence

$$p \cos N' - q \sin N = \cos\delta \cos N' \cos\nu + \sin\delta \cos(N - N') \sin\nu = \cos\beta \cos(\nu - \lambda)$$
$$p_1 \cos N' - q_1 \sin N' = \cos\delta \cos N' \sin\nu - \sin\delta \cos(N - N') \cos\nu = \cos\beta \sin(\nu - \lambda)$$

and (18) becomes, putting in the numerator

$$\cos^2(\nu - \lambda) = 1 - \sin^2(\nu - \lambda)$$

and considering that

$$\sin(N - N') \sin^2(\nu - \lambda) ,$$

on account of ν being very nearly $= \lambda$ or $\lambda + 180$, becomes a negligible quantity:

$$(19) \qquad \sin(\nu - \lambda) = \frac{m' \cos\beta \cdot k \sin(N - N') [1 - \kappa \operatorname{tg}\beta \cdot \cos(\nu - \lambda)]}{\kappa \cdot n' - c \cos\beta \cdot m' k \sin(N - N') \cdot \sin(\nu - \lambda)}$$

This gives as a first approximation putting on the right hand side $\nu = \lambda$,

$$\sin(\nu - \lambda) = \frac{1}{\kappa \quad n'}[m' \cos\beta \quad \kappa \quad \sin(N - N') [1 - \kappa \operatorname{tg}\beta]$$

which becomes known when κ and $\sin(N - N')$ become known. These, too, require the process of successive approximation. We put first $c = c_0 + k$, with which from (10) we get a first approximation of $\sin\varphi_1$; c and this value of $\sin\varphi_1$ give

$$(20) \qquad \kappa = \sqrt{1 - c^2 - e^2 \sin\varphi_1} \quad (\text{always} > 0) ,$$

and we can now compute ξ' and η' by (11), hence shall know the value of $\sin(N - N')$, with which (19) will give an improved value of ν and (9a) an improved value of $\sin\varphi_1$. We can now compute more accurately $c = c_0 + k \cos(N - N')$ etc., etc. When φ_1 has been computed until no sensible change is produced by a further attempt of successive approximation, we may compute ξ, η and ζ by $\xi = b \sin N - c \cos N$, $\eta = b \cos N + c \sin N$ where b and c are now known from (5), besides ζ.

The point of intersection of the limiting parallel of latitude and of the limiting shadow curve will then be given by

$$(21) \qquad \cos\varphi_1 \sin(T + \tau - \omega - a) = \xi$$
$$\cos\varphi_1 \cos(T + \tau - \omega - a) = -\eta \sin\delta + \zeta \cos\delta$$

where $T + \tau$ is the angular value of the sidereal time $T + \tau$ and ω the west longitude of the required point from the prime meridian.

It will have been noticed that we obtain by the previous process two values of φ_1, but it is obvious that only *that* will be admissible which gives

$$\cos z = \sin\varphi \sin\delta + \cos\varphi \cos\delta \cos(\mu - a)$$

a positive quantity, the other indicates a point on the surface of the *Earth* which is the intersection of the generatrix of the cylindrical shadow after its traversion of the *Earth'* body, and, of course, here the occultation remains invisible. But we may restrict the double sign of (10), upon which the successive approximation, to be followed up, depend, still further. We have in general, introducing the geographical latitude φ instead of the geocentric φ' and putting $1 : \sqrt{1 - e^2 \sin^2\varphi} = \rho \cos\varphi' : \cos\varphi$:

$$\zeta : \rho = \sin\mu \quad \sin\nu = (\cos\varphi' : \cos\varphi) \; [\cos z - e^2 \sin\delta \sin\varphi]$$

hence for the cosine of the zenith distance of the star:

$$\cos z = (\cos\varphi : \cos\varphi'), \sin\mu \cdot \nu + e^2 \sin\delta \sin\varphi \quad (22)$$

which for $\nu = \lambda$ or $\nu = \lambda \pm 180°$ becomes

$$\cos z = \pm (\cos\varphi : \cos\varphi') \sin\mu \sin\lambda + e^2 \sin\delta \sin\varphi$$

or eliminating $\sin\lambda$ (from 8), *viz.*: $\sin\lambda = \sin\delta : \cos\beta$

$$\cos z = \sin\delta\, [\pm (\cos\varphi : \cos\varphi') (\sin\mu : \cos\beta) + e^2 \sin\varphi]$$

Since $\sin\mu : \cos\beta$ can always be determined a positive quantity, we have, disregarding for the present, the small term in e^2:

$\cos z > o$ for $\delta > o$	and $\nu = \lambda$	(a)
$\cos z > o$ for $\delta < o$	and $\nu = \lambda \pm 180°$	(b)
$\cos z < o$ for $\delta > o$	and $\nu = \lambda \pm 180°$	(c)
$\cos z > o$ for $\delta < o$	and $\nu = \lambda$	(d)

The visibility of the occultation requires $\cos z > o$ hence (c) and (d) are not admissible. We conclude that in (10) and subsequently in the general expression (9a) we must take the upper sign for $\delta > o$, and the lower sign for $\delta < o$. This rule, however, must be reversed if, in the above expression for $\cos z$, the absolute value of $e^2 \sin\varphi$ is greater than the first term in the bracket, and its sign is the reverse of that of this term.

The previous investigation settles the question as to the most northerly or southerly limiting parallel, according as k is used with the positive or negative sign. But when either one has been determined

there remains yet the limiting parallel of the other limiting shadow curve to be determined. There we have the two points at which the star is seen in the horizon while the points are at their least distance from the shadow axis. Since now $\cos z = o$, we get from (22)

$$\rho \cdot \sin\mu \sin\nu = \kappa \sin\nu = -e^2 \sin\delta \operatorname{tg}\varphi \quad \rho\cos\varphi'$$

or since,

$$\operatorname{tg}\varphi = \operatorname{tg}\varphi_1 : \sqrt{1 - e^2} \qquad \rho\cos\varphi' = \cos\varphi_1$$

we have

$$(23) \quad \zeta = \kappa \sin\nu = -(e^2 : \sqrt{1 - e^2}) \sin\delta \sin\varphi_1$$

If we substitute this value of ζ in

$$\rho \sin\varphi' = \sqrt{1 - e^2} \cdot \sin\varphi_1 = \eta\cos\delta + \zeta\sin\delta$$

we get

$$\frac{1 - e^2\cos^2\delta}{\sqrt{1 - e^2}} \cdot \sin\varphi_1 = \eta\cos\delta$$

Let

$$\rho_1 \sin\delta_1 = \sin\delta\ , \ \rho_1\cos\delta_1 = \sqrt{1 - e^2}\ \cos\delta$$
$$\therefore \rho_1^2 = 1 - e^2\cos^2\delta$$

and we get

$$\sin\varphi_1 = (\cos\delta_1 : \rho_1)\ \eta$$

or substituting the previously obtained value of η in terms of $\rho\ \mu\ \nu$ and N:

$$\sin\varphi_1 = (\cos\delta_1 : \rho_1)\,[\kappa \cdot \cos\nu\cos N + c\sin N] \quad (24)$$

If here we restore the value of $\kappa = \sqrt{1 - e^2 - e^2\sin^2\varphi_1}$ and solve for $\sin\varphi_1$, we have:

$$\sin\varphi_1 = \frac{c\,\rho_1\cos\delta_1\sin N \pm \cos\delta_1\cos N\cos\nu\sqrt{(1 - e^2)\,(\rho_1^2 + e^2\cos^2\delta_1\cos^2 N\cos^2\nu) - e^2 c^2\sin^2 N}}{\rho_1^2 + e^2\cos^2\delta_1\cos^2 N\cos^2\nu} \quad (25)$$

which combined with (23), solved for $\sin\nu$, *viz.:*

$$(25) \quad \sin\nu = -\frac{e^2}{\sqrt{1 - e^2}} \cdot \frac{\sin\delta\sin\varphi_1}{\sqrt{1 - e^2 - e^2\sin^2\varphi_1}}$$

establishes the complete solution of the problem of determining the second limiting parallel.

From (25) it is seen that ν is in the vicinity of 0° or 180°. If we use either value of ν as an initial value, we get with adopting first $c = c_0 \pm k$ an initial value of φ_1, with which we may either recompute (25) or proceed first to improve c as in the former limiting parallel. It will be easy and therefore needless, to make further statements as to the grouping of the values of φ_1, derived from (9*a*) and from (25) so as to obtain the actual limiting parallels between which, on the spheroidal surface of the *Earth*, the occultation may be observed. In (25) $\cos\delta_1 \cos N > 0$ if N is so determined that $-90° < N < +90°$.

Broderick, Cal., January, 1919.

A NEW VARIABLE STAR,

By E. E. BARNARD.

I have found on my photographs with the BRUCE telescope what is either a variable star with a great range of light and an extremely long period, or a queer kind of nova. Its closely approximate position is:

1855.0	α 17h 31m 44s	$\delta - 11° 53'.4$
1900.0	17 34 14	−11 55.2

Professor S. I. BAILEY of the Harvard College Observatory kindly informs me that it is not a known variable star and that MISS LEAVITT has looked it up on the Harvard photographs and finds that the first photograph to show it was made on July 9, 1909, when its estimated magnitude was 13.9, and that it is recorded on eighteen plates between March 21, 1910, and June 13, 1918. It is not shown on any Harvard plates previous to 1909 as far back as 1891.

My own plates show it with little change since May 1, 1911, to February 9, 1919, while plates from March 6, 1905, to July 19, 1895, do not show it. Some of these plates show stars perhaps as faint as 16th magnitude. It is not on the following WOLF-PALISA charts:

No. 131	1904 June 13	Exposure 3h 0m
No. 148	1905 June 28	Exposure 2 14

Professor BAILEY informs me that its magnitude on my photograph of July 5, 1915, with 2h 16m exposure is approximately 10.5.

I have not yet looked for the star visually.

Yerkes Observatory, Williams Bay, Wisconsin.
1919, February 28.

ELEMENTS AND EPHEMERIS OF *1915 YJ*,

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral T. B. Howard, U. S. Navy, Superintendent U. S. Naval Observatory.]

1915 YJ was discovered photographically 1915 Feb. 18 by Mr. G. H. Peters at Washington. The only observations available are three by Mr. Peters with a twin 10-inch triplet, first published in *A. J.* **29**, 61. The plates have been remeasured by him and reduced by the writer by the method of Wilson and Gingrich, *Goodsell Obs. Pub.* No. 5.

1915 G. M. T.	Astrographic α (1900.0)	Astrographic δ (1900.0)	Images	Largest residuals	Comparison Stars Astr. Toul	Remarks	$p_\alpha\rho$	$p_\delta\rho$	Residuals from orbit $\cos\delta\ \Delta\alpha$	$\Delta\delta$
	° ′ ″	° ′ ″		″	° h m				″	″
(1) Feb. 18.71528	149 15 11.3	+9 10 54.0	poor	0.7	+9.09 56, 24, 30, 32, 33, 35, 79, 80	Near plate edge	9.059n	0.638	0.0	0.0
(2) Feb. 19.69382	149 1 54.8	+9 13 30.3	poor	0.7	+9.09 56, 24, 30, 32, 33, 35, 79, 80	Near plate edge	9.956n	0.638	0.0	0.0
(3) Mar. 9.65521	145 17 45.4	+9 58 21.3	poer	1.5	+9.09 40 43, 45, 46, 53, 57, 72, 77 78, 87, 97	Near plate edge	7 783	0.627	0.0	0.0

"Astrographic," as in the *Greenwich Observations*, denotes the position of an object derived by using in the reduction the mean places of comparison stars at the beginning of the year.

The orbit, dervied by Leuschner's method, *Lick Pub.* **7**, yields the above residuals. It is to be noted that no theoretical difficulty was experienced, in spite of the very unequal intervals. By using the same group of stars, errors in the star places have no relative effect on (1) and (2).

Elements and Constants for Equator

Epoch = 1915 Apr. 11.5 G. M. T.

$M = 120^\circ.82933 \qquad m_0 = 12.0$

$\mu = 0^\circ.2053444 \qquad g = 8.4$

$\log a = 0.454148$

$e = 0.331165$

$$\left.\begin{aligned} i &= 11^\circ\ 0'\ 29''.5 \\ \Omega &= 317\ \ 2\ \ 8\ .6 \\ \omega &= 51\ 41\ 23\ .2 \end{aligned}\right\} 1900.0$$

$$\left.\begin{aligned} x &= r[9.996291] \sin\,(99^\circ\ 15'\ 21''.1 + V) \\ y &= r[9.931897] \sin\,(\ \ 4\ 41\ 11\ .3 + V) \\ z &= r[9.728292] \sin\,(21\ 13\ 15\ .3 + V) \end{aligned}\right\} 1900.0$$

1913 Ephemeris ($9^m.8$)

G. M. T.	α_{1900}		δ_{1900}		(log r) log ρ
1913	h m		° ′		
Sept. 8.5	1 53.4		+28 16		(0.280)
		0.3		111	
18.5	1 53.1		+30 7		0.024
		3.9		85	
28.5	1 49.2		+31 32		0.006
		7.1		48	
Oct. 8.5	1 42.1		+32 20		9.994
		8.7		11	
18.5	1 33.4		+32 31		9.990
		8.8		26	
28.5	1 24.6		+32 5		9.996
		6.9		55	
Nov. 7.5	1 17.7		+31 10		0.010
		3.8		69	
17.5	1 13.9		+30 1		0.033
		0.2		71	
27.5	1 13.7		+28 50		0.061
		3.5		62	
Dec. 7.5	1 17.2		+27 48		(0.307)

1915 Ephemeris ($12^m.9$)

G. M. T.	α_{1900}		δ_{1900}		(log r) log ρ
1915	h m		° ′		
Jan. 1.5	10 30.2		+ 8 9		(0.515)
		3.7		4	
11.5	10 26.5		+ 8 5		0.403
		5.8		6	
21.5	10 20.7		+ 8 11		0.391
		7.6		16	
31.5	10 13.1		+ 8 27		0.383
		8.6		22	
Feb. 10.5	10 4.5		+ 8 49		0.380
		9.1		26	
20.5	9 55.4		+ 9 15		0.382
		8.7		26	
Mar. 2.5	9 46.7		+ 9 41		0.390
		7.6		24	
12.5	9 39.1		+10 5		0.403
		5.8		17	
22.5	9 33.3		+10 22		0.420
		3.9		9	
Apr. 1.5	9 29.4		+10 31		(0.542)

1916 Ephemeris ($13^m.5$)

G. M. T.	α_{1900}		δ_{1900}		(log r) log ρ
1916	h m		° ′		
Feb. 25.5	13 7.1		−19 17		(0.578)
		5.1		5	
Mar. 6.5	13 2.0		−19 22		0.469
		6.6		8	
16.5	12 55.4		−19 14		0.457
		7.8		24	
26.5	12 47.6		−18 50		0.449
		8.2		35	
Apr. 5.5	12 39.4		−18 15		0.445
		7.9		43	
15.5	12 31.5		−17 32		0.446
		7.1		49	
25.5	12 24.4		−16 43		0.452
		5.8		48	
May 5.5	12 18.6		−15 55		0.461
		4.2		45	
15.5	12 14.4		−15 10		0.474
		2.3		37	
25.5	12 12.1		−14 33		(0.572)

It is greatly desired that plates at other observatories be searched, especially those in the discovery opposition, 1915. If images are found, please communicate with this observatory.

The above is volunteer work and is unchecked.

U. S. Naval Observatory, Washington, D. C., 1919, Jan. 3.

MEASURES OF DOUBLE STARS,

MADE WITH THE 10½ INCH REFRACTOR OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

Most of the stars in this list are well known binaries. In addition are stars of recent discovery from a list kindly furnished by PROF. ERIC DOOLITTLE. The second list was difficult to measure and the accidental error large on account of their faintness. The star-places are for 1880.

479 OΣ 20 0h 48m +18° 32′

190 +	°	″					
18.049	302.1	0.59	6.0	7.0		600	
18.052	302.4	0.52	6.0	7.5		600	
19.052	300.3	0.42	6.5	7.5		400	
19.071	298.0	0.56	6.0	7.0		400	
18.05	302.2	0.56	6.0	7.2	2		
19.06	299.2	0.49	6.2	7.2	2		

182 Σ 73 0h 48m +22° 59′

18.041	42.6	0.99	6.0	6.4		400	
18.049	44.4	0.73	6.0	6.3		400	
18.052	44.2	0.78	6.0	6.2		600	
18.088	45.0	0.98	6.0	6.3		400	
19.052	47.2	0.62	6.3	6.0		400	
19.071	48.2	0.74	6.2	6.0		400	
19.079	45.8	0.84	. .	. .		400	
18.06	44.0	0.85	6.0	6.3	4		(1)
19.07	47.1	0.73	6.2	6.0	3		

612 β 303 1h 3m +23° 9′

16.923	287.9	0.62	7.0	7.4		400
16.975	284.5	0.69	7.0	7.2		400
16.95	286.2	0.65	7.0	7.3	2	

711 H 2036 1h 14m −16° 26′

15.750	7.4	1.78	7.6	7.8		400
15.843	6.4	1.53	7.7	7.5		400
15.865	7.9	1.44	7.7	8.0		400
15.82	7.2	1.58	7.7	7.8	3	

1015 Σ 186 1h 50m +1° 15′

18.038	218.0	1.03	7.0	7.2		400
18.041	219.6	. . .	.	. .		600
18.044	216.3	1.08		.		400
18.049	219.5	0.89	7.0	7.2		400
18.052	220.4	0.97	7.0	7.1		600
18.088	220.0	1.09	7.0	7.3		400
19.052	220.4	0.87	7.0	7.5		400
19.071	219.1	1.02	7.0	7.4		400
19.073	219.6	1.09	7.0	7.4		400
19.079	220.3	1.02	. .	.		400
18.05	219.0	1.01	7.0	7.2	5-4	
19.07	219.8	1.00	7.0	7.4	4	

1127 Σ 305 2h 41m +18° 52′

1900+	°	″				
18.041	315.3	3.26	7.0	7.7		400
18.049	316.1	3.25	.			400
18.052	316.5	3.16	7.0	7.8		600
18.060	314.2	3.08	7.0	7.8		400
18.077	315.7	3.09	.	.		300
19.052	315.2	3.13	7.2	8.0		400
19.068	315.6	3.13	7.0	7.8		400
19.071	316.1	3.15	6.7	7.5		400
19.073	313.4	3.20	7.0	7.8		400
18.06	315.6	3.17	7.0	7.5	5	
19.06	315.1	3.15	7.0	7.8	4	

1512 Σ 333 2h 52m +20° 52′

14.920	201.3	1.54	5.5	6.2		400	
15.972	203.0	1.44	6.0	6.5		600	
18.038	202.9	1.46	6.0	6.4		400	
18.041	201.0	1.40	6.0	6.4		600	
18.049	203.2	1.42	5.7	6.0		400	
18.052	202.6	1.31	6.0	6.5		600	
18.085	202.1	1.40	6.0	6.5		400	
19.052	203.4	1.42	6.0	6.3		400	
19.068	202.7	1.30	6.0	6.4		400	
19.071	203.4	1.48	6.0	6.5		400	
19.073	203.4	1.44	. .	.		400	
15.45	202.2	1.49	5.8	6.4	2		(2)
18.05	202.4	1.40	5.9	6.3	5		
19.07	203.2	1.41	6.0	6.4	4		

... JON 236 4h 3m +1° 6′

17.146	217.5	4.31	9.2	9.6		400
17.157	218.0	3.79	9.2	9.6		400
17.162	218.8	4.43	9.4	10.0		400
18.049	225.5	3.91	9.5	10.5		400
18.085	227.4	3.49	9.7	10.0		400
18.088	221.7	3.93	9.5	10.5		400
17.61	221.5	3.98	9.4	10.0	6	

... ESPIN 168 4h 12m +36° 26′

18.038	282.3	7.34	8.5	11.5	400

2166 Δ 6 $4^h 54^m$ +14° 20′

1900+							
16.061	89.8	0.81	8.7	8.7		400	
16.094	87.0	0.94	8.8	8.8		400	
16.146	94.4	1.03	8.6	8.9		400	
16.10	90.4	0.93	8.7	8.8	3		(3)

... Espin 170 $5^h 8^m$ +34° 17′

17.143	19.1	14.15	8.0	10.5	300

3596 *Sirius* $6^h 40^m$ −16° 33′

17.168		11.03	..	.	400	
17.173	72.6	11.22	.	8.0	400	
17.187	72.4	11.08		7.5	400	
17.242	74.7	10.92			400	
17.19	73.2	11.06		7.8 3-4		(4)

3760 Σ 1007 Rej. $6^h 54^m$ +12° 53′

A and *B*

16.149	207.7	68.34	8.2	7.8		400
16.206	207.5	68.36	8.4	8.0		400
16.212	207.7	68.21	8.5	8.2		400
16.19	207.6	68.30	8.4	8.0	3	

B and *C*

16.149	299.9	15.08	7.8	12.0		400
16.206	298.2	15.46	8.0	12.0		400
16.212	299.4	16.05	8.2	12.0		400
16.223	299.6	15.20	8.2	12.0		400
16.20	299.3	15.45	8.0	12.0	4	

B and *D*

16.149	246.3	21.81	..	10.5		400
16.206	246.2	22.38	.	10.5		400
16.212	245.6	22.39		10.7		400
16.19	246.0	22.19		10.6	3	

... *A.G.* -- $7^h 23^m$ +26° 1′

17.250	172.4	1.84	9.0	8.8		400
17.269	170.8	1.72	9.0	9.1		400
17.280	168.8	1.84	8.8	9.0		300
17.27	170.6	1.80	8.9	9.0	3	

... *A.G.* $7^h 24^m$ +25° 25′

1900+							
17.250	298.2	4.00	8.7	9.2		400	
17.269	298.0	3.98	8.8	9.6		400	
17.280	296.0	3.66	8.8	9.5		300	
17.27	297.4	3.88	8.8	9.4	3		(5)

4122 *Castor* $7^h 27^m$ +32° 9′

A and *B*

18.315	215.6	5.20	3.0	4.2		400	
18.329	217.2	4.88	3.0	4.2		400	
18.331	216.0	5.03	3.0	4.4		400	
18.334	216.5	5.17	3.0	4.5		400	
18.33	216.3	5.07	3.0	4.3	4		(6)

A and *C*

18.315	164.8	73.32		9.0		400
18.331	165.0	73.47		8.0		400
18.32	164.9	73.40		8.5	2	

Remarks

(1) Comparison with Rabe's orbit, *A. N.* 4735, gives

O − C	1918.06	−6°.1	+0″.14
	1919.07	−6°.0	+0″.95

Jonckheere's observations compared with Rabe's orbit give

1910.26	−0°.8	+0″.13
1914.85	−3°.6	+0 .19
1916.03	−4°.3	+0 .12

(2) Maximum separation probably reached at 1″.5.

(3) Probably fixed.

(4) Comparison with Aitken's orbit, *Lick Bul.* No. 316, gives

O − C +0°.6 +0″.20

(5) Companion placed in opposite quadrant by other observers.

(6) Comparison with Lohse's orbit, Potsdam Vol. 20, gives

O − C −0°.4 −0″.05

CONTENTS.

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THE

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No. 750

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MEASURES OF DOUBLE STARS,

(Continued from A. J. 749)

MADE WITH THE 10½ INCH REFRACTOR OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

1477 ξ *Cancri* 8ʰ 5ᵐ +18° 1′

A and *B*

1900+	°	″					
18.279	291.0	0.82	5.0	5.6		600	
18.282	291.2	0.79	..	..		600	
18.296	289.8	0.85	.	.		400	
18.315	291.6	0.79	5.0	5.3		600	
18.29	290.9	0.81	5.0	5.4	4		(7)

AB and *C*

18.279	111.8	5.30		6.0		600
18.282	111.8	5.05				600
18.296	111.1	5.10				400
18.315	111.4	5.24		5.8		600
18.29	111.5	5.17		5.9	4	

... Barnard 8ʰ 29ᵐ +20° 2′

17.250	162.1	....	10.7	11.3		400
17.258	165.9	5.18	10.5	11.0		400
17.280	162.4	4.54	9.7	10.7		300
18.271	163.5	4.69	10.8	11.3		400
17.51	163.4	4.80	10.4	11.1	4-3	

... Roe 72 8ʰ 44ᵐ +31° 5′

17.259	189.5	6.39	10.0	11.0		300
17.280	189.3	6.53	9.5	11.0		300
17.286	190.6	6.48	9.5	10.7		300
17.305	190.6	6.54	9.5	10.8		300
17.28	190.0	6.48	9.6	10.9	4	

5030 Σ 1338 9ʰ 13ᵐ +38° 42′

18.331	176.6	1.26	7.5	8.0		400
18.340	173.0	1.48	6.8	7.0		600
18.348	181.0	1.31	7.0	7.3		400
18.359	177.9	1.44	7.0	7.5		600
18.34	178.4	1.37	7.1	7.4	4	

5103 Σ 1356 9ʰ 22ᵐ +9° 35′

1900+	°	″					
18.274	130.2	0.96	6.0	7.0		400	
18.282	124.4	1.04	6.0	7.0		400	
18.285	129.0	0.99	6.0	7.0		400	
18.296	125.5	0.96	6.0	6.8		400	
18.28	127.3	0.99	6.0	7.0	4		(8)

5235 A. C. 5 9ʰ 47ᵐ −7° 32′

18.282	60.2	0.63	5.0	5.2		400	
18.285	59.8	0.62	5.0	5.3		400	
18.315	62.3	0.61	5.0	6.2		600	
18.334	65.4	0.56	5.0	5.4		600	
18.340	64.3	0.52	5.0	5.3		600	
18.31	62.4	0.59	5.0	5.5	5		(9)

... Fox 10ʰ 2ᵐ +25° 36′

17.286	68.8	8.88	10.5	11.4		300
17.302	70.5	7.29	11.0	11.8		300
18.296	72.5	7.44	11.0	11.6		300
17.63	70.6	7.87	10.8	11.6	3	

5365 OΣ 315 10ʰ 10ᵐ +18° 20′

17.381	199.4	0.82	7.0	7.3		400	
17.395	201.6	0.98	7.0	7.5		400	
17.403	201.1	0.94	.	..		400	
18.274	199.6	0.96	7.5	7.8		400	
18.307	200.0	1.02	6.8	7.3		400	
18.310	199.9	0.93	7.0	8.0		400	
18.315	199.8	1.01	6.7	7.3		600	
17.39	200.7	0.91	7.0	7.4	3		
18.30	199.8	0.98	7.0	7.6	1		(10)
							(11)

5388 Σ 1424 $10^h 13^m$ $+20° 27'$

1900	°	″					
18.334	116.5	3.94	3.0	4.2		600	
18.340	117.5	3.75	3.0	5.0		600	
18.348	117.0	3.77	3.0	4.5		400	
18.359	115.8	3.77	3.0	4.0		400	
18.362	117.1	3.75	3.0	4.0		400	
18.35	116.8	3.80	3.0	4.3	5		

... Espin 925 $10^h 13^m$ $+48° 20'$

17.305	165.9	5.84	9.5	12.0		300	
18.307	164.6	....	..	...		400	
17.81	165.2	5.84	9.5	12.0	2-1		

... Jon 736 $10^h 24^m$ $+15° 21'$

17.286	202.8	1.81	9.5	9.8		300	
17.340	200.3	1.28	10.5	11.0		400	
18.271	204.1	1.70	9.5	10.0		400	
18.290	200.6	1.62	10.0	10.5		400	
18.296	203.1	2.59	9.5	10.2		400	
17.90	202.2	1.80	9.8	10.3	5		

... Skinner 14 $10^h 26^m$ $-15° 47'$

17.280	80.9	7.36	9.2	9.7		400	
17.286	82.7	7.26	9.3	9.6		300	
18.310	82.0	6.84	9.5	9.7		300	
18.315	81.3	6.98	9.3	9.8		600	
17.80	81.7	7.11	9.3	9.7	4		

... Espin — $10^h 31^m$ $+45° 30'$

18.312	271.6	7.87	9.5	11.5		400	
18.348	272.6	7.58	9.2	11.5		400	
18.33	272.1	7.72	9.4	11.5	2		

... Espin 603 $10^h 35^m$ $+48° 49'$

18.312	97.9	12.83	9.3	11.0		400	

... Espin 1246 $10^h 36^m$ $+43° 41'$

18.312	55.3	3.40	9.3	10.0		400	

5557 Σ 1472 $10^h 41^m$ $+13° 40'$

17.354	38.9	38.58	8.6	8.9		300	
17.360	38.0	38.28	8.5	9.0		300	
17.368	38.5	38.37	8.5	9.2		400	
17.36	38.5	38.41	8.5	9.0	3		

... A. G. — $10^h 42^m$ $+13° 51'$

17.354	231.2	36.23	9.3	9.7		300	
17.360	231.3	36.99	9.5	10.0		300	
17.368	230.4	37.16	9.2	10.5		400	
17.36	231.0	36.79	9.3	10.1	3		(11)

... Espin — $10^h 46^m$ $+44° 38'$

1900	°	″					
17.303	44.9	8.84	8.5	9.5		300	
17.360	45.5	8.37	8.8	10.2		...	
17.370	44.0	8.03	9.0	10.2		300	
17.381	45.1	9.24	9.0	10.0		400	
18.312	43.7	8.79	8.8	9.5		400	
17.55	44.6	8.65	8.8	9.9	5		

A and *C*

17.370	230.1	49.88	..	11.0		300	
17.381	230.3	49.57	.	11.2		400	
18.312	229.9	49.36	..	11.0		400	
17.69	230.1	49.60	.	11.1	3		(12)

... Espin 433 $10^h 51^m$ $+30° 32'$

17.354	220.7	....	9.8	11.3		400	
17.360	220.9	6.13	9.5	11.3		400	
17.370	221.9	5.61	9.5	11.5		400	
17.36	221.2	5.87	9.6	11.4	3-2		

... Arg. 73 $10^h 52^m$ $+9° 53'$

17.302	71.9	16.55	9.4	9.6		300	
17.305	68.3	16.49	9.3	9.5		300	
17.340	70.9	16.97	9.5	10.0		300	
17.354	71.2	16.52	9.3	9.5		400	
17.33	70.6	16.63	9.4	9.6	4		(12)

... A. G. — $10^h 53^m$ $+26° 6'$

17.302	80.0	4.76	8.4	8.7		300	
17.305	77.6	5.21	8.5	8.7		400	
17.340	81.6	4.62	8.4	8.7		300	
17.351	78.8	5.01	8.5	8.6		400	
17.32	79.5	4.90	8.4	8.7	4		

... A 1772 $10^h 54^m$ $-13° 52'$

18.315	212.2	4.08	9.5	11.0		400	
18.340	212.4	3.84	9.2	10.2		400	
18.33	212.3	3.96	9.4	10.6	2		

5659 Σ 1504 $10^h 58^m$ $+4° 17'$

17.370	288.4	1.17	7.7	7.5		400	
17.381	289.9	1.17	7.7	7.5		400	
17.395	289.4	1.10	7.6	7.5		400	
17.38	289.2	1.15	7.7	7.5	3		

5765 Σ 1536 $11^h 18^m$ $+11° 12'$

18.271	38.0	1.94	4.0	7.0		400	
18.307	35.9	2.06	4.0	7.0		400	
18.310	37.4	2.22	4.0	7.0		600	
18.312	37.2	2.04	4.0	7.0		600	
18.30	37.1	2.06	4.0	7.0	4		

... Espin 725 $12^h 4^m$ $+47° 15'$

1900+	°						
17.373	58.4	6.19	9.5	9.8		300	
17.381	58.6	6.74	9.5	9.8		400	
17.392	58.9	7.47	9.5	10.4		400	
17.395	58.1	7.01	9.5	9.8		400	
17.39	58.3	6.85	9.5	10.0	4		

6158 Σ 1639 $12^h 18^m$ $+26° 15'$

17.395	344.7	0.57	6.0	7.5		600	
18.329	342.9	0.64	6.0	6.7		600	
17.86	343.8	0.60	6.0	7.1	2		

6211 H 1218 $12^h 29^m$ $-16° 10'$

16.255	261.9	11.25	6.5	11.0		400	
16.307	260.7	11.58	7.0	11.0		400	
16.318	263.0	11.75		.		400	
16.29	261.9	11.53	6.8	11.0	3		

... Espin 924 $12^h 29^m$ $-16° 10'$

17.395	220.9	3.96	9.5	10.2		400	

... *A. G.* $12^h 33^m$ $+13° 31'$

17.373	324.8	8.57	9.0	11.0		400	
17.381	326.0	8.60	9.3	11.5		400	
17.395	325.8	8.79	9.3	10.8		400	
17.403	325.3	8.15	9.2	10.5		400	
17.39	325.5	8.53	9.2	11.0	4		

6213 γ *Vir* $12^h 36^m$ $-0° 47'$

1900+							
17.390	323.9	5.96	..			600	
17.403	324.0	5.93	3.0	3.1		400	
17.40	324.0	5.94	3.0	3.1	2		(13)

6406 Σ 1728 $13^h 4^m$ $+18° 10'$

17.436	192.7	0.49	5.5	5.8		600	
17.483	192.1	0.49	.	..		600	
17.46	192.4	0.49	5.5	5.8	2		(14)

6455 Σ 1734 $13^h 15^m$ $+3° 34'$

17.142	188.0	0.95	7.0	7.7		400	
17.483	189.1	1.02	7.0	8.0		400	
17.46	188.6	0.98	7.0	7.8	2		

6611 Σ 1785 $13^h 44^m$ $+27° 35'$

17.436	354.4	1.19	7.0	8.0		600	
17.442	354.1	1.15				400	
17.483	354.6	1.21	7.0	7.4		400	
17.45	354.4	1.18	7.0	7.7	3		

6780 Σ 1819 $14^h 9^m$ $+3° 41'$

1900+							
17.414	342.8	1.17	8.1	8.0		400	
17.436	344.2	1.19	8.2	8.0		400	
17.483	344.6	1.16	7.7	7.8		400	
17.44	343.9	1.17	8.0	7.9	3		(15)

... *A. G.* $14^h 32^m$ $+11° 33'$

17.373	357.1	26.58	9.0	9.8		400	
17.392	356.8	.	9.3	9.8		300	
17.395	357.4	26.08	9.2	9.8		400	
17.403	356.5	26.07	9.3	9.7		400	
17.414	358.4	26.54	9.0	9.7		400	
17.40	357.2	26.32	9.2	9.8	5-4		

6955 Σ 1865 $14^h 35^m$ $+14° 15'$

17.395	138.7	0.86	4.2	4.0		400	
17.414	139.7	0.86	4.0	4.0		400	
17.436	140.8	0.80	4.0	4.2		600	
17.526	142.6	0.82	4.2	4.0		400	
17.44	140.4	0.84	4.1	4.0	4		

7019 OΣ 288 $14^h 48^m$ $+16° 12'$

17.395	185.7	1.41	6.5	7.3		600	
17.433	186.8	1.57	6.5	7.3		400	
18.472	186.9	1.56	6.5	7.5		400	
17.77	186.5	1.51	6.5	7.4	3		

... Jon. 441 $15^h 1^m$ $+18° 33'$

17.373	153.1	3.36	9.5	10.5		400	
17.403	155.4	..	..	...		400	
17.414	156.5	4.36	9.5	11.3		400	
17.436	159.8	3.38	10.0	11.0		400	
17.41	156.2	3.70	9.7	10.9	4-3		

7195 β 352 $15^h 11^m$ $-26° 33'$

16.480	65.8	14.15	8.3	10.0		400	
17.483	66.7	13.93	8.5	10.0		400	
16.98	66.2	14.04	8.4	10.0	2		

7211 Lv 6 $15^h 13^m$ $-26° 35'$

16.480	28.6	17.26	8.3	11.0		400	
17.483	29.2	17.15	8.0	10.5		400	
16.98	28.9	17.20	8.2	10.8	2		

7251 Σ 1937 $15^h 18^m$ $+30° 43'$

17.395	70.9	0.69	5.0	5.4		600	
17.433	67.9	0.72	5.0	5.2		600	
17.526	68.2	0.69	5.1	5.0		600	
17.45	69.0	0.70	5.0	5.2	3		(16)

... Jox 445 15h 56m +10° 42′

1900+							
17.463	292.7	3.09	10.0	10.7		400	
17.483	293.2	2.47	10.5	11.0		400	
17.47	293.0	2.78	10.2	10.8	2		

... *A. G. Camb.* 7446 15h 56m +28° 27′

17.483	227.8	11.43	9.0	10.2		300	
17.502	227.4	11.69		.		300	
17.49	227.6	11.56	9.0	10.2	2		(17)

... Jox. 446 15h 58m +10° 45′

17.463	4.0	3.87	9.5	9.7		400	
17.483	2.9	4.21	10.0	10.3		400	
17.47	3.4	4.04	9.8	10.0	2		

7563 Σ 2032 16h 10m +34° 10′

18.644	218.7	5.16	5.0	5.7		600	
18.649	220.0	5.14	5.0	5.8		400	
18.652	218.9	4.96	5.0	6.5		400	
18.654	219.4	5.18	5.0	6.0		600	
18.65	219.2	5.11	5.0	6.0	4		

7619 Σ 2055 16h 25m +2° 15′

17.433	79.5	0.96	4.0	6.0		600	
17.502	76.8	0.81	4.0	6.0		400	
18.633	80.3	0.85	4.0	6.5		400	
18.635	77.5	0.93	4.0	6.0		400	
18.644	77.4	0.81	4.0	6.0		400	
18.649	77.7	0.88	4.0	6.0		400	
17.47	78.2	0.88	4.0	6.0	2		
18.64	78.2	0.87	4.0	6.1	4		

7717 ζ *Her.* 16h 37m +31° 49′

17.433	102.9	1.76	3.0	6.5		600	
17.521	99.1	1.53	3.0	6.0		400	
18.635	98.0	1.87	3.0	6.5		400	
18.644	98.3	1.64	3.0	6.0		600	
18.649	96.7	1.73	3.0	6.0		600	
18.652	97.9	1.60	3.0	5.5		600	
18.750	95.2	1.63	3.0	6.0		600	
18.764	97.0	1.72	3.0	6.0		600	
18.772	93.6	1.95	3.0	6.0		100	
17.48	101.0	1.64	3.0	6.2	2		
18.70	96.8	1.73	3.0	6.0	7		

7783 Σ 2107 16h 47m +28° 52′

18.652	30.1	0.65	6.5	8.5		600	
18.665	31.7	0.69	6.0	7.5		100	
18.685	27.9	0.66	6.0	7.7		400	
18.737	31.8	0.64	6.0	7.5		400	
18.772	26.9	0.50	6.0	7.0		400	
18.70	29.7	0.63	6.1	7.6	5		

8038 Σ 2173 17h 24m −0° 58′

1900+	°	″					
18.619	155.9	0.84	6.0	6.3		400	
18.633	155.0	0.78	6.0	6.5		400	
18.635	154.9	0.84	6.0	6.4		400	
18.644	157.8	0.88	6.0	6.5		400	
18.63	155.9	0.84	6.0	6.4	4		(18)

8303 Σ 2262 17h 56m −80° 11′

15.681	261.6	1.81	6.0	7.0		400	
15.692	262.4	1.85	6.0	7.0		400	
15.708	262.7	1.96	6.0	6.8		400	
15.715	261.4	2.06	5.5	6.3		400	
18.649	261.4	2.03	5.0	5.7		600	
18.652	262.5	1.88	5.0	5.6		600	
18.654	262.7	2.05	5.0	5.6		600	
18.657	262.1	2.04	5.0	5.4		400	
15.70	262.0	1.92	5.9	6.8	4		
18.65	262.2	2.00	5.0	5.6	4		

8310 Σ 2272 17h 59m +2° 33′

15.654	140.1	4.56				400	
15.682	139.5	4.54	4.0	6.5		400	
15.709	139.8	4.65	4.0	6.0		400	
18.633	136.3	5.21	4.0	6.0		400	
18.635	136.0	5.61	4.0	6.5		300	
18.641	135.3	5.30	4.0	6.0		300	
18.644	135.0	5.24	4.0	6.0		400	
18.742	135.0	5.10	4.0	6.5		400	
18.745	135.8	5.08		. .		400	
15.68	139.8	4.58	4.0	6.2	3		(19)
18.67	135.6	5.26	4.0	6.2	6		

8380 Σ 2281 18h 4m +3° 58′

18.644	78.4	0.58	6.0	7.5		600	
18.649	72.1			.		400	
18.665	74.3	0.57	6.0	7.8		400	
18.685	74.5	0.63	6.0	8.0		600	
18.737	76.6	0.54	6.0	7.5		600	
18.68	75.2	0.58	6.0	7.7	5-4		(20)

8619 β 419 18h 26m −7° 55′

15.728	43.1		8.0	9.0		400	
16.714	39.0			.		400	
16.732	42.6	1.03	8.0	9.3		400	
16.763	40.5	0.90	8.0	9.0		400	
16.48	41.1	0.96	8.0	9.1	4-2		(21)

8663 OΣ 358 18h 31m +16° 53′

1900+	°	″					
15.681	187.6	1.76	7.5	7.8		400	
15.692	186.2	1.83	7.0	7.5		400	
15.708	188.0	1.85	7.4	7.6		400	
17.789	186.3	1.62	7.0	7.2		400	
17.811	187.2	1.72	7.0	7.2		400	
17.850	186.0	1.81	7.0	7.2		400	
17.877	188.0	1.68	7.0	7.2		600	
18.644	186.8	2.03	7.5	7.5		400	
18.745	187.1	1.94	7.0	7.2		400	
15.69	187.3	1.81	7.3	7.6	3		(22)
17.83	186.9	1.71	7.0	7.2	4		
18.69	187.0	1.98	7.2	7.3	2		

9003 Σ 2444 18h 59m +25° 53′

15.714	314.8	23.50	8.5	10.0		400
15.752	313.8	23.46	8.8	9.5		600
15.73	314.3	23.48	8.6	9.8	2	

9014 β 466 19h 0m +10° 39′

15.681	163.7	1.45	9.0	10.3		400
15.708	164.5	1.45	9.0	10.0		400
15.769	162.5	1.71	9.0	10.5		400
15.72	163.6	1.51	9.0	10.3	3	

9313 Schj. 22 19h 21m −12° 23′

16.467	347.3	1.42	8.1	8.0		400
18.608	350.0	..	..	.		400
18.633	350.8	1.30	8.0	8.0		400
18.644	348.8	1.40	8.0	8.0		400
18.649	348.3	1.50	8.0	8.1		400
18.657	348.7	1.19	8.4	8.2		400
18.720	350.1	1.20	8.5	8.3		400
16.47	347.3	1.42	8.1	8.0	1	
18.65	349.5	1.32	8.2	8.1	6-5	

9319 Σ 2525 19h 22m +27° 5′

15.654	304.6	0.76	8.0	8.3		400	
15.681	308.3	0.76	8.0	8.0		600	
15.692	304.1	0.80		..		400	
15.708	306.9	0.78	8.0	8.4		400	
18.633	307.0	0.84	8.0	8.4		400	
18.657	307.4	0.87		...		400	
18.726	304.9	0.93	7.7	7.8		600	
18.737	306.1	0.98	8.0	8.2		400	
18.739	306.3	1.00				400	
18.742	306.0	0.88				400	
15.68	306.0	0.78	8.0	8.2	4		(23)
18.71	306.3	0.92	7.9	8.1	6		

9500 Σ 2556 19h 34m +21° 59′

1900+							
15.708	121.1	0.45	6.0	6.5		600	
15.782	116.1	0.42	6.0	6.5		600	
15.826	117.8	0.42				600	
15.77	118.4	0.43	6.0	6.5	3		(24)

... 19h 41m +10° 12′

16.776	193.4	1.78	10.5	11.0		600	
16.842	193.6	1.79	10.0	11.0		400	
16.81	193.4	1.78	10.2	11.0	2		(25)

9602 Σ 2576 19h 41m +33° 20′

15.711	103.5	2.08	8.3	8.5		400	
15.728	103.6	2.06	8.0	8.2		400	
15.752	102.6	1.89	8.2	8.3		600	
15.73	103.2	2.01	8.2	8.3	3		(26)

9601 β 828 19h 41m +5° 52′

15.728	7.7	2.51	8.2	10.5		400
15.752	8.5	2.45	8.3	10.0		600
15.74	8.1	2.48	8.2	10.2	2	

9650 OΣ 387 19h 44m 35° 0′

18.685	311.8	0.70	6.5	6.8		600
18.720	311.8	0.69	7.0	8.0		400
18.726	310.4	0.63	7.0	7.6		600
18.734	311.7	0.67	7.0	8.0		400
18.72	311.4	0.67	6.9	7.6	4	

9833 OΣ 395 19h 57m +24° 36′

15.692	107.6	0.63	5.5	6.0		400
15.708	104.6	0.61	5.5	6.3		600
15.714	107.0	0.57	5.7	6.2		600
15.70	106.4	0.60	5.6	6.2	3	

... Jon. 503 20h 0m +11° 23′

18.649	292.9	4.52	9.8	10.5		400
18.652	291.5	4.11	10.0	10.3		400
18.720	291.7	4.33	10.5	11.0		400
18.67	292.0	4.32	10.1	10.6	3	

... Espin 203 20h 4m +35° 7′

18.742	129.4	5.96	8.7	10.0		400
18.747	129.2	5.73	8.5	10.3		300
18.770	132.4	5.70	8.5	10.2		300
18.75	130.3	5.80	8.6	10.2	3	

10005 Σ 2649 20h 8m +31° 43′

15.728	151.6	23.91	8.0	9.5		400	
15.752	151.7	23.70	8.0	9.0		600	
15.74	151.6	23.80	8.0	9.2	2		(27)

10076 β 441 $20^h\ 13^m$ $+28°\ 46'$

1900+	°	″				
15.703	65.4	5.26	7.0	11.0		400
15.752	65.2	6.00	7.0	11.3		600
15.769	62.0	5.97	7.0	12.0		600
15.74	64.2	5.74	7.0	11.4	3	

10238 A 293 $20^h\ 23^m$ $+41°\ 28'$

18.665	120.7	1.60	8.7	9.0		300

... Jon. 130 $20^h\ 26^m$ $+41°\ 25'$

18.657	266.5	2.21	9.0	9.4		400
18.665	266.0	2.22	9.0	9.5		300
18.66	266.2	2.22	9.0	9.4	2	

... Fox 37 $20^h\ 28^m$ $+13°\ 1'$

18.742	228.6	1.84	9.1	9.5		400

... Espin 247 $20^h\ 32^m$ $+36°\ 26'$

18.657	143.6	5.47	9.8	11.3		400

... *A.G.* — $20^h\ 40^m$ $+27°\ 59'$

18.649	19.7	2.92	9.0	9.5		400
18.657	19.3	2.35	9.0	9.5		300
18.65	19.5	2.64	9.0	9.5	2	

10519 β 364 $20^h\ 42^m$ $+24°\ 58'$

15.711	227.6	1.05	8.5	8.5		400
15.752	228.1	1.13	8.3	8.5		600
15.769	224.6	1.23	8.6	8.5		600
15.74	226.8	1.14	8.5	8.5	3	

10559 Σ 2729 $20^h\ 45^m$ $-6°\ 4'$

17.847	340.2	0.54	7.0	7.5		600	
18.726	344.3	0.47	6.0	7.0		600	
18.737	342.1	0.48	7.0	8.0		600	
18.44	342.2	0.50	6.7	7.5	3		(28)

... *A.G.* — $21^h\ 1^m$ $+29°\ 4'$

17.850	83.9	5.12	8.5	9.7		300
18.649	79.7	5.08	9.3	9.6		300
18.657	83.8	5.01	9.6	10.0		300
18.38	82.5	5.07	9.5	9.8	3	

10736 β 173 $21^h\ 1^m$ $-10°\ 41'$

15.708	111.4	2.10	8.5	10.5		400
15.780	115.0	2.25	8.5	10.0		100
16.790	113.1	1.64	8.3	9.5		300
16.900	116.1	2.02	8.3	10.3		400
16.29	114.8	2.00	8.4	10.1	1	

10910 β 838 $21^h\ 15^m$ $+2°\ 37'$

1900+	°	″				
06.894	98.9	1.40	8.0	10.0		400
14.800	107.2	1.19	8.2	10.2		400
15.708	104.8	1.45	8.0	10.3		600
12.47	103.6	1.35	8.1	10.2	3	

10911 OΣ 435 $21^h\ 15^m$ $+2°\ 23'$

14.800	210.2	0.61	8.0	8.3		400
15.708	215.7	0.48	7.8	8.3		400
15.25	213.0	0.54	7.9	8.3	2	

... Espin 520 $21^h\ 34^m$ $+27°\ 54'$

17.762	35.5	6.69	9.5	10.0		400
17.789	36.7	6.96	10.2	11.0		300
17.850	37.6	7.21	9.5	9.8		300
17.80	36.6	6.95	9.7	10.3	3	

11246 Σ 2825 $21^h\ 41^m$ $+0°\ 18'$

15.708	114.0	0.87	8.0	8.8		600
15.802	111.9	0.93	8.2	8.8		400
15.76	113.0	0.90	8.1	8.8	2	

... *A.G.* — $21^h\ 42^m$ $+28°\ 31'$

17.850	159.7	9.95	9.5	10.0		300
17.874	161.2	9.69	10.0	10.5		300
18.608	156.5	9.37	9.5	11.0		400
18.11	159.1	9.67	9.7	10.5	3	

... Doo. — $21^h\ 59^m$ $+10°\ 33'$

18.780	327.6	8.47	10.0	10.7		400

11593 β 476 $22^h\ 9^m$ $+30°\ 48'$

16.938	94.5	2.79	9.0	10.5		400

11611 β 477 $22^h\ 10^m$ $+30°\ 49'$

16.938	43.2	6.50	8.8	10.0		300

11713 Σ 2909 $22^h\ 23^m$ $-0°\ 38'$

15.870	308.9	3.10	4.0	4.0		600
15.876	306.0	3.04	..			400
17.856	306.5	2.84	4.0	4.2		400
16.53	307.1	2.99	4.0	4.1	3	

11936 Σ 2942 $22^h\ 39^m$ $+38°\ 50'$

A and *B*

15.750	276.3	2.73	6.5	9.5		400
15.785	282.1	..	.	.		400
15.824	281.2	2.88	6.5	8.5		400
15.79	279.9	2.80	6.5	9.0	3-2	

A and *C*

1900+ 15.750	233.8	11.56		12.5		600

... Vanderdonck 2 $22^h 48^m$ $+7° 45'$

18.608	132.3	3.20	9.2	9.4		400
18.868	123.2	3.44	10.3	10.0		400
18.74	127.8	3.32	9.7	9.7	2	

12185 Σ 2981 $23^h 3^m$ $-9° 29'$

06.790	110.9	3.67	9.0	9.0		300
06.796	109.9	3.92	..	..		400
14.813	113.0	3.94	9.0	9.3		400
15.747	108.7	3.71	9.0	9.4		400
15.750	111.4	3.73	9.2	9.5		400
11.98	110.8	3.79	9.0	9.3	5	

... Fox 47 $23^h 12^m$ $+9° 53'$

17.850	279.9	4.87	9.0	10.5		400
17.885	281.1	4.62	8.7	10.3		400
17.87	280.5	4.74	8.8	10.4	2	

... Jon. 296 $23^h 17^m$ $+6° 15'$

17.841	137.4	4.71	9.5	10.0		400
17.973	137.0	4.27	9.7	10.5		400
17.91	137.2	4.49	9.6	10.2	2	

12639 Σ 3046 $23^h 50^m$ $-10° 10'$

14.838	252.5	3.12	8.4	9.0		300
14.842	250.8	3.06	8.5	9.0		300
14.84	351.6	3.09	8.4	9.0	2	

12700 β 482 $23^h 56^m$ $+62° 39'$

A and *B*

16.878	342.7	4.24	9.0	10.0		300

A and *C*

16.878	124.1	10.33	..	12.0		300

Remarks

(7) Comparison with Doberck's orbit, *A. N.* 4144, gives

O — C $-6°.2$ $-0''.07$

(8) Comparison with Doberck's orbit, *A. N.* 4144, gives

O — C $-0°.2$ $-0''.01$

(9) Comparison with Schoenberg's orbit, *A. N.* 4260, gives

O — C $+3°.0$ $-0''.03$

(10) Motion still appears to be rectilinear.

(11) Angle differs 180° from earlier measures.

(12) No other measures.

(13) Comparison with Doberck's orbit, *A. N.* 3364, gives

O — C $-1°.1$ $-0''.32$

(14) Comparison with Doberck's orbit, *A. N.* gives 4276,

O — C $+0''.08$

(15) Distance decreasing.

(16) Comparison with Lohse's orbit, Potsdam Vol. 20, gives

O — C $+0°.2$ $-0''.03$

(17) Distance double earlier measures.

(18) Comparison with Lohse's orbit gives

O — C $+1°.5$ $-0''.11$

(19) Comparison with Lohse's orbit gives

O — C	1915.68	$-1°.0$	$-0''.13$
	1918.67	$-0°.7$	$-0\ .01$

(20) Motion still seems almost rectilinear.

(21) Slow decrease in angle and distance probable.

(22) Angle and distance changing very slowly.

(23) Comparison with Doberck's orbit, *A. N.* 4515, gives

O — C	1915.68	$+2°.3$	$+0''.05$
	1918.71	$+4°.6$	$+0\ .15$

(24) Motion practically rectilinear.

(25) New?

(26) Orbital motion, distance diminishing rather rapidly.

(27) Distance slowly decreasing due to proper-motion.

(28) Comparison with Aitken's Orbit, *Lick Pub.* 12, gives

O — C $-6°.1$ $-0''.04$

Minneapolis, Minn., 1919, Jan. 30.

NOTE ON APPARENT PLACE OF ASTEROIDS AND COMETS,

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral T. B. Howard, U. S. Navy, Superintendent U. S. Naval Observatory.]

It is desired to call attention to the fact that the apparent place reduction of the comparison star published with a visual equatorial observation of an asteroid or comet is dispensable.

Let R_* = apparent place reduction of comparison star,
R_0 = apparent place reduction of object,
$dR = R_0 - R_*$

It is practically universal to employ mean place in orbit work and to assume dR negligible. This assumption is equivalent to making no essential use of R_*, for mean place of object uncorrected for annual aberration may be obtained by applying $\Delta\alpha$ and $\Delta\delta$ directly to mean place of comparison star. (Where mean place corrected for annual aberration is used, the necessity of computing the aberration remains unchanged.) If the orbit computer wishes to take account of dR, he obtains it either by computing R_0 to form $R_0 - R_*$, or directly by the differential formulæ. The latter method is not longer than the computation of either R_* or R_0. Therefore, since the labor of the orbit computer is in no way increased, the computation and publication of R_*, the apparent place reduction of comparison star, is strongly recommended to be discontinued.

General discussion by observers and computers is invited.

U. S. Naval Observatory, Washington, D. C., 1919, February 23.

NOTE ON THE NEW VARIABLE STAR.*

(1900.0 α 17h 34m 14s δ −11° 55′.2)

By E. E. BARNARD.

The star was observed visually on March 11, with the large telescope, and the following position obtained.

1919.0 α 17h 35m 20s.03 δ −11° 54′ 31″.5

It was also measured at the same time with respect to two other stars in the field with it.

Variable and 14M.5 star preceding
P. A. 276°.6 Dist. 30″.6

Variable and 10M — 11M star following
P. A. 74°.7 Dist. 167″.6

The variable was estimated to be brighter than 9½ magnitude on the BD scale. The star appeared white, certainly not a decided yellow or red, though there may have been a very slight tinge of yellow which was lost in the bad seeing. A small ocular spectroscope over the eye-piece showed that the spectrum did not consist of bright lines.

I have photographs with the Bruce 6-inch and 10-inch lenses of this observatory on June 29, 1908 with an exposure of 4h 0m, with the position of the star near the center of the plate, which shows stars of probably 15½ magnitude, but the variable is not shown.

Yerkes Observatory,
Williams Bay, Wisconsin.
1919, March 15.

*See A. J. 749

NEW ASTRONOMICAL WORK.

Astrographic Catalogue 1900.0 Hyderabad Section, Vol. II. Measures of rectangular co-ordinates and diameters of 61,378 star-images, Dec. −18°, by R. J. Pocock. Edinburgh, 1918.

Sur la Reduction des Cliches Astrophotographiques et la Conversion des Mesures en AR et D, by W. Gillenberg. *Meddelanden fran Lunds Astronomiska Observatorium.* Series II, Nr. 18.

Studies in Stellar Statistics, Stellar Clusters and related celestial phenomena, by C. V. L. Charlier. *Meddelanden fran Lunds Astronomiska Observatorium.* Series II, Nr. 19.

Sur le Groupe des Étoiles a Hélium dans la Constellation d'Orion, by Osten Bergstrand. *Nova Acta Regia Societatis Scientiarum Upsaliensis.* Ser. IV, Vol. 5, No. 2.

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OBSERVATIONS DE PLANÈTES ET DE LA COMÈTE PÉRIODIQUE WOLF,

FAITES A L'OBSERVATOIRE DE BESANÇON, EQUATORIAL COUDÉ 0^m 33 D'OUVERTURE,

PAR M. P. CHOFARDET.

Dates	Tm Besançon	Δ A. R.	Δ D. P.	Cp.	A. R. app.	log. f. p.	D. P. app.	log. f. p.	Réd. au j.		*
					(2) *Pallas*						
1918	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Juin 12	13 24 15	−1 33.49	−10 22.8	12 , 9	16 50 10.58	9.335	63 57 55.4	0.544*n*	+3.39	+ 2.7	1
14	11 49 59	−2 1.33	− 4 36.2	9 , 12	16 48 35.17	8.780	64 0 24.1	0.505*n*	+3.40	+ 2.3	2
18	10 53 37	+3 5.08	+ 5 57.3	9 , 12	16 45 25.85	8.073*n*	64 9 6.2	0.505*n*	+3.41	+ 1.9	3
					(9) *Metis*						
Juin 14	11 16 5	−0 55.00	+10 7.9	9 , 6	14 1 43.34	9.427	99 34 45.1	0.854*n*	+3.35	+16.3	4
29	11 37 50	+3 18.93	+ 9 47.8	6 , 8	14 1 57.19	9.553	100 14 20.7	0.839*n*	+3.23	+16.0	5
					(16) *Psyche*						
Juin 5	11 37 10	+1 13.31	+ 9 42.9	9 , 6	14 24 23.61	9.331	100 0 12.6	0.861*n*	+3.50	+15.8	6
6	9 47 6	+0 47.75	+ 8 17.9	9 , 6	14 23 58.04	8.569	99 58 47.5	0.870*n*	+3.49	+15.7	6
					(20) *Massalia*						
Mai 15	10 57 39	+1 57.20	− 6 13.9	9 , 6	15 18 15.45	8.953*n*	107 45 40.9	0.900*n*	+3.71	+13.6	7
16	10 48 7	+0 57.99	−10 14.7	9 , 6	15 17 16.25	8.991*n*	107 41 40.1	0.900*n*	+3.75	+13.6	7
31	11 22 43	−0 4.56	− 2 16.3	12 , 9	15 3 37.74	8.986	106 44 37.1	0.897*n*	+3.78	+14.5	8
Juin 1	11 3 11	−0 50.86	− 5 37.2	9 , 6	15 2 51.44	8.847	106 41 16.2	0.898*n*	+3.78	+14.5	8
29	10 29 0	−1 48.53	−11 20.2	12 , 10	14 50 39.94	9.341	105 17 47.1	0.881*n*	+3.66	+14.6	9
Juil. 11	10 31 0	−0 49.67	− 6 42.5	12 , 8	14 51 38.71	9.460	105 52 24.3	0.869*n*	+3.57	+14.1	9
					(30) *Urania*						
Mars 11	12 12 8	−0 52.28	− 9 46.9	12 , 9	9 28 23.73	9.311	76 29 5.5	0.709*n*	+2.93	+14.3	10
12	12 9 5	−2 35.20	+ 5 50.1	9 , 12	9 27 46.01	9.316	76 26 30.0	0.704*n*	+2.93	+14.3	11
					(31) *Euphrosyne*						
Juin 1	9 51 36	−1 55.71	− 1 55.0	9 , 6	12 32 18.84	9.295	87 39 59.4	0.796*n*	+2.88	+16.5	12
3	11 14 13	−2 5.57	+11 57.2	9 , 6	12 32 8.96	9.501	87 53 51.4	0.801*n*	+2.86	+16.3	12

Dates	Tm Besançon	Δ A. R.	Δ D. P.	Cp.	A. R. app.	log. f. p.	D. P. app.	log. f. p.	Réd. au j		*
					(52) Europa						
	h m s	m s	″		h m s		° ′ ″		s	″	
Mars 8	10 50 44	+0 6.25	+ 6 49.2	12, 9	10 54 9.00	9.031n	76 24 4.5	0.691n	+3.00	+17.8	13
9	9 55 37	−0 35.83	+ 0 54.4	12, 9	10 53 26.93	9.283n	76 18 9.7	0.700n	+3.01	+17.8	13
Mai 10	10 31 29	+4 42.83	− 2 4.8	9, 12	10 39 33.13	9.475n	74 48 33.6	0.711n	+2.54	+13.1	14
Juin 7	10 12 0	−3 13.27	+ 0 40.2	9, 7	10 57 4.16	9.569	76 54 19.3	0.756n	+2.32	+12.4	15
					(60) Echo						
Juin 14	10 42 12	+1 9.22	+ 1 14.5	9, 6	15 0 10.81	9.102	102 58 19.9	0.880n	+3.69	+13.9	16
Juil. 1	10 31 23	+2 44.14	+10 27.1	9, 12	14 55 32.34	9.352	102 46 26.9	0.871n	+3.59	+13.5	17
					(69) Hesperia						
Juin 1	10 33 48	−1 7.58	− 1 33.5	9, 6	13 8 40.06	9.314	91 58 31.9	0.822n	+3.08	+17.0	18
3	11 42 18	−1 7.99	− 2 37.8	9, 6	13 8 39.64	9.488	91 57 27.5	0.819n	+3.07	+16.9	18
					(87) Sylvia						
Juin 7	11 51 22	−2 19.36	+ 6 46.8	9, 6	15 39 30.42	9.122	106 1 17.3	0.892n	+3.91	+11.3	19
					(169) Zelia						
Mars 8	12 9 54	−0 17.47	+10 41.8	12, 9	10 6 16.78	9.077	75 17 46.7	0.680n	+3.01	+15.9	20
9	11 14 37	−1 10.83	+ 8 11.0	12, 9	10 5 23.42	8.470	75 15 12.8	0.677n	+3.01	+15.8	20
					(170) Maria						
Mars 11	12 58 10	+2 23.21	+ 1 21.1	9, 12	9 25 16.76	9.430	88 1 17.7	0.800n	+2.79	+16.0	21
12	11 10 19	+1 44.52	+ 0 15.2	9, 9	9 24 38.06	9.048	88 0 11.9	0.797n	+2.78	+16.1	21
					(184) Deiopée						
Mars 9	10 30 4	−2 40.77	− 1 18.8	9, 12	11 14 38.15	9.219n	85 35 48.6	0.780n	+2.93	+18.6	22
					(196) Philomele						
Juin 6	10 23 46	+1 51.49	− 4 37.1	9, 6	14 46 19.68	8.800	102 21 59.3	0.880n	+3.63	+15.0	23
7	11 23 1	+1 18.33	− 4 19.8	9, 6	14 45 46.52	9.237	102 22 16.6	0.874n	+3.63	+15.0	23
					(336) Lacadiera						
Mars 11	13 42 39	+1 51.40	+ 4 18.1	9, 8	11 56 37.92	9.032	98 56 1.4	0.863n	+2.93	+18.4	24
12	10 37 47	+1 4.69	− 1 17.3	12, 9	11 55 51.21	9.304n	98 50 26.1	0.858n	+2.93	+18.5	24
13	10 35 16	+0 10.62	− 7 39.1	12, 9	11 54 57.15	9.296n	98 44 4.4	0.857n	+2.94	+18.6	24
					(362) Havnia						
Mai 15	10 6 21	−0 55.02	− 8 52.1	12, 9	12 36 20.57	9.025	93 24 3.5	0.832n	+3.03	+19.1	25
16	9 23 13	−1 14.09	− 7 56.8	9, 6	12 36 1.50	8.586	93 24 58.8	0.833n	+3.03	+19.1	25
					(385) Ilmatar						
Mars 9	12 8 28	+0 15.34	− 5 1.8	12, 9	11 4 50.17	8.280	84 29 6.0	0.768n	+2.94	+18.4	26
Juin 3	10 18 8	−2 14.67	+ 8 8.3	9, 6	10 54 39.49	9.551	89 39 10.6	0.810n	+2.30	+17.1	27
5	10 26 10	−1 12.71	− 0 0.5	9, 6	10 56 24	9.564	89 53 46	0.811n	+2.29	+17.1	28

Dates	Tm Besançon	ΔA.R.	ΔD.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		*
					(409) *Aspasia*						
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mai 2	11 56 35	−1 57.77	− 7 14.8	9, 6	14 27 53.07	8.211	111 54 51.5	0.916*n*	+3.63	+16.4	29
					(144) *Gyptis*						
Mai 15	11 39 5	+1 17.99	− 1 30.1	9, 6	15 55 36.98	8.900*n*	99 43 46.9	0.868*n*	+3.61	+10.9	30
16	11 12 54	−0 34.27	− 5 25.0	9, 6	15 54 47.92	9.066*n*	99 38 10.4	0.866*n*	+3.62	+10.8	31
31	10 45 5	−0 37.68	+10 7.8	9, 6	15 42 16.20	8.602*n*	98 22 14.7	0.862*n*	+3.71	+10.7	32
Juin 1	11 27 33	−1 27.08	+ 5 47.3	9, 6	15 41 26.81	8.636	98 17 54.2	0.861*n*	+3.72	+10.7	32
					(498) *Tokio*						
Mai 10	11 48 17	+1 23.96	− 0 30.6	9, 6	14 25 4.17	8.786	91 11 26.2	0.819*n*	+3.35	+15.8	33
15	12 20 54	−2 4.85	− 0 20.6	9, 6	14 20 42.31	9.194	91 4 1.5	0.817*n*	+3.37	+15.5	34
16	10 12 57	−2 50.53	− 1 17.1	9, 12	14 19 56.63	8.743*n*	91 3 4.9	0.818*n*	+3.37	+15.4	34
					(511) *Davida*						
Mars 12	9 19 15	+1 51.09	− 9 29.7	12, 16	7 31 18.13	9.119	60 58 40.0	0.453*n*	+2.81	+3.3	35
13	9 18 31	+2 5.21	− 8 18.3	9, 12	7 31 31.77	9.138	60 57 5.8	0.456*n*	+2.78	+3.3	36
					(704) *Interamnia*						
Mars 13	10 59 18	−1 37.06	− 5 40.7	12, 9	10 29 9.90	8.070*n*	104 11 34.9	0.889*n*	+2.87	+19.1	37
					Comète périodique Wolf						
Août 28	8 54 8	+2 23.74	+ 3 33.7	9, 12	20 2 12.06	8.915*n*	66 10 56.2	0.545*n*	+3.78	−22.3	38
29	8 48 21	+1 22.04	+ 1 46.6	6, 3	20 1 50.59	8.925*n*	66 24 30.0	0.549*n*	+3.78	−22.5	39
30	8 37 14	−1 54.87	+ 1 35.1	12, 16	20 1 30.85	8.986*n*	66 38 34.0	0.555*n*	+3.78	−22.7	40
31	8 56 48	+0 42.41	+ 1 26.9	12, 12	20 1 13.01	8.717*n*	66 53 15.0	0.554*n*	+3.76	−22.8	41
Sept. 2	8 38 22	+0 33.64	+ 6 27.4	12, 9	20 0 44.04	8.850*n*	67 23 28.4	0.564*n*	+3.75	−23.0	42
3	8 38 3	−0 15.83	+ 1 32.3	12, 12	20 0 32.45	8.804*n*	67 39 14.2	0.568*n*	+3.75	−23.1	43
6	8 43 35	+0 56.88	+ 6 45.0	12, 9	20 0 12.71	8.481*n*	68 28 53.8	0.579*n*	+3.71	−23.4	44
Oct. 3	8 25 26	−2 5.50	− 6 6.1	9, 12	20 14 21.14	9.009	77 27 57.9	0.701*n*	+3.58	−25.0	45
5	8 56 49	+1 2.43	+ 4 2.9	12, 9	20 16 40.35	9.215	78 10 52.8	0.714*n*	+3.55	−24.8	46
8	6 52 3	+0 54.20	+ 2 0.4	9, 6	20 20 18.66	8.590*n*	79 12 17.8	0.716*n*	+3.54	−24.9	47
9	6 48 1	−0 32.91	−11 23.4	15, 9	20 21 38.34	8.616*n*	79 33 8.7	0.720*n*	+3.55	−25.0	48
10	7 6 32	−2 3.52	− 1 47.9	9, 12	20 23 1.58	7.603*n*	79 54 15.7	0.723*n*	+3.56	−25.1	49
11	6 48 22	+0 57.81	− 1 38.3	12, 9	20 24 24.81	8.500*n*	80 14 41.0	0.726*n*	+3.54	−24.9	50
28	6 17 25	+2 13.30	− 4 39.5	9, 12	20 53 51.06	8.298*n*	85 41 48.3	0.776*n*	+3.53	−25.1	51
29	6 21 32	+0 51.05	− 1 43.4	12, 9	20 55 53.52	7.970*n*	85 59 4.2	0.778*n*	+3.54	−25.2	52
30	6 18 5	+1 48.96	+ 5 20.2	9, 9	20 57 56.36	8.082*n*	86 16 13.4	0.780*n*	+3.54	−25.2	53
31	6 14 1	+2 3.19	+ 0 2.5	9, 12	21 0 1.58	8.203*n*	86 32 59.3	0.782*n*	+3.54	−25.1	54
Nov. 5	6 15 55	+2 29.70	− 5 28.8	3, 4	21 10 53.21	7.450	87 53 4.8	0.793*n*	+3.55	−25.1	55
9	6 15 58	+2 18.75	− 7 2.1	9, 12	21 20 1.95	8.160	88 51 47.7	0.798*n*	+3.56	−25.2	56
20	6 5 24	+0 52.03	+ 8 43.7	12, 9	21 46 57.61	8.391	91 7 34.5	0.816*n*	+3.60	−25.4	57
21	6 10 11	−2 32.43	− 4 15.7	9, 12	21 49 31.41	8.548	91 18 5.8	0.817*n*	+3.63	−25.5	58
22	6 5 2	+3 17.90	+ 0 13.7	9, 12	21 52 5.32	8.459	91 28 10.0	0.818*n*	+3.60	−25.3	59
23	5 59 56	−0 32.20	− 8 0.7	12, 9	21 54 40.05	8.347	91 37 57.8	0.819*n*	+3.62	−25.4	60
30	5 52 22	−0 53.80	+ 0 26.1	12, 9	22 13 9.60	8.396	92 37 23.7	0.826*n*	+3.65	−25.4	61
Déc. 6	5 58 33	+0 50.29	− 5 36.5	9, 12	22 29 28.17	8.685	93 15 53.6	0.830*n*	+3.66	−25.3	62

POSITÍONS MOYENNES DES ÉTOÍLES DE COMPARAISON.

*	A.R. 1918.0	D.P. 1918.0	Autorités		*	A.R. 1918.0	D.P. 1918.0	Autorités	
	h m s	° ′ ″				h m s	° ′ ″		
1	16 51 40.68	64 8 15.5	*A.G. Cam.(Engl.)*	7891	32	15 42 50.17	98 11 56.2	*A.G. Wien-Ottak.*	5503
2	16 50 33.10	64 4 58.0	*A.G. Cam.(Engl.)*	7882	33	14 23 36.86	91 11 41.0	*A.G. Nicolajew*	3745
3	16 42 17.36	64 3 7.0	*A.G. Cam.(Engl.)*	7803	34	14 22 43.79	91 4 6.6	*A.G. Nicolajew*	3741
4	14 2 34.99	99 24 20.9	*rap. à Star A.G.W. Ottak*	4989	35	7 29 24.23	61 8 6.4	*A.G. Cam. (Engl.)*	4042
5	13 58 35.03	100 4 16.9	*A.G. Wien-Ottak.*	4985	36	7 29 26.78	61 5 20.8	*A.G. Cam. (Engl.)*	4044
6	14 23 6.80	99 50 13.9	*A.G. Wien-Ottak.*	5101	37	10 30 44.09	104 16 56.5	*A.G. Cam. (U.S.)*	4009
7	15 16 14.51	107 51 41.2	*A.G. Washington*	5632	38	19 59 44.54	66 7 44.8	*A.G. Berlin B*	7442
8	15 3 38.52	106 46 38.9	*A.G. Washington*	5577	39	20 0 24.77	66 23 5.9	*A.G. Berlin B*	7449
9	14 52 24.81	105 58 52.7	*A.G. Washington*	5516	40	20 3 21.94	66 37 21.6	*A.G. Berlin B*	7485
10	9 29 13.98	76 38 38.1	*rap. à star 11*		41	20 0 26.84	66 52 11.2	*Abbadia*	11414
11	9 30 18.28	76 20 25.6	*A.G. Leipzig I*	3794	42	20 0 6.65	67 17 24.0	*A.G. Berlin B*	7445
12	12 34 11.67	87 41 37.9	*A.G. Albany*	4529	43	20 0 44.53	67 38 5.0	*A.G. Berlin B*	7451
13	10 53 59.75	76 16 57.5	*A.G. Leipzig I*	4163	44	19 59 12.11	68 22 32.2	*A.G. Berlin B*	7438
14	10 34 47.76	74 50 25.3	*A.G. Berlin A*	4216	45	20 16 23.06	77 34 29.0	*A.G. Leipzig I*	7853
15	11 0 15.11	76 53 26.7	*A.G. Leipzig I*	4184	46	20 15 34.37	78 7 14.7	*A.G. Leipzig I*	7841
16	14 58 57.90	102 56 51.5	*rap. à A.G. Cam. (U.S.)*	5263	47	20 19 20.92	79 10 42.3	*A.G. Leipzig I*	7889
17	14 52 44.61	102 35 46.3	*A.G. Cam. (U.S.)*	5236	48	20 22 7.70	79 44 57.1	*A.G. Leipzig I*	7915
18	13 9 44.56	91 59 48.4	*A.G. Nicolajew*	3550	49	20 25 1.54	79 56 28.7	*A.G. Leipzig II*	10117
19	15 41 45.87	105 54 19.2	*A.G. Washington*	5764	50	20 23 23.45	80 16 44.2	*A.G. Leipzig II*	10093
20	10 6 31.24	75 6 46.0	*A.G. Berlin A*	4061	51	20 51 34.23	85 46 52.9	*A.G. Albany*	7335
21	9 22 50.76	87 59 40.6	*A.G. Albany*	3787	52	20 54 58.93	86 1 12.8	*A.G. Albany*	7352
22	11 17 15.99	85 36 48.8	*A.G. Albany*	4253	53	20 56 3.86	86 11 18.4	*A.G. Albany*	7361
23	14 44 24.56	102 26 21.4	*A.G. Cam. (U.S.)*	5198	54	20 57 54.85	86 33 21.9	*A.G. Albany*	7369
24	11 54 43.59	98 51 24.9	*A.G. Wien-Ottak.*	4436	55	21 8 19.96	87 58 58.7	*A.G. Albany*	7427
25	12 37 12.56	93 32 36.5	*Abbadia*	3917	56	21 17 39.64	88 59 15.0	*A.G. Nicolajew*	5434
26	11 4 31.89	84 33 49.4	*A.G. Leipzig II*	5702	57	21 46 1.98	90 59 16.2	*A.G. Nicolajew*	5517
27	10 56 51.86	89 30 45.2	*A.G. Nicolajew*	3165	58	21 52 0.21	91 22 47.0	*A.G. Nicolajew*	5532
28	10 57 35	89 53 29	pos.app.(Carte Palisa)		59	21 48 43.82	91 28 21.6	*A.G. Nicolajew*	5525
29	14 29 17.21	112 1 49.9	*Cincinnati*	2497	60	21 55 8.63	91 46 23.9	*A.G. Strasbourg*	7678
30	15 54 15.38	99 45 6.1	*rap. à star 31*		61	22 13 59.75	92 37 23.0	*A.G. Strasbourg*	7764
31	15 55 18.57	99 43 24.6	*A.G. Wien-Ottak.*	5564	62	22 28 34.22	93 21 55.4	*A.G. Strasbourg*	7827

* 4 — *A.G. Wien-Ottak.* 4989 : Δ *A.R.* = $+2^m 58^s.63$; Δ *D.P.* = + 3′ 12″.6
* 10 — * 11 : Δ *A.R.* = −1 5 .20 ; Δ *D.P.* = +18 12 .5
* 16 — *A.G. Camb. (U.S.)* 5263 : Δ *A.R.* = +1 54 .70 ; Δ *D.P.* = − 3 40 .9
* 30 — * 31 : Δ *A.R.* = −1 3 .19 ; Δ *D.P.* = + 1 41 .5

Remarques.

Planètes — (9) *Metis*, Juin 29, observation faite un peu près de l'horizon. (20) *Massalia*, Mai 31, le Coudé est secoué par le vent. (498) *Tokio*, Mai 10, le ciel est nébulent et la planète peu visible. Mai 16, au moment de l'observation la planète est très voisine d'une étoile de même grandeur.

Comète périodique Wolf — Aout 28, la Comète, estimée de 12ᵉ grandeur, est une petite nébulosité de 20″ de diamètre ayant une vague condensation à peu près centrale. Août 29, le ciel se couvre. Sept. 2, la Comète est de grandeur 11.5; la chevelure, mesurant de 25″ a 30″ de diamètre, a un petit noyan, d'intensité variable, un peu décentré vers la N. W. Oct. 3, la Comète est de 10ᵉ grandeur; la tête, ronde, de 45″ de diamètre, a une condensation centrale bien prononcée. Oct. 8, les mesures sont interrompues par des nuages. Oct. 9, la Comète, de grandeur 10.5, a son noyan décentré vers W. Oct. 29, la Comète est estimée de 10ᵉ grandeur.

Nov. 5, le ciel se couvre. Nov. 23, la Comète, de grandeur 9.5, a une condensation floue, mais bien définie, au centre d'une tête ronde de 50″ de diamètre. Déc. 6, la Comète est estimée de 11^e grandeur.

Observatoire de Besançon, 1919, février 28.

MICROMETER OBSERVATIONS OF WOLF'S ASTEROID *ALINDA* (1918 DB).

By E. E. BARNARD.

After the announcement by WOLF of the discovery of this important asteroid, I secured photographs of it with the Bruce telescope on February 9 and 10. I finally located it visually with the large telescope on February 12 with the aid of a photograph of it made on the same night with the Bruce telescope by MISS CALVERT, and the measures of that night were secured. After this it was followed with the aid of extrapolated positions kindly supplied me by PROFESSOR VAN BIESBROECK until the appearance of the ephemeris computed at Berkeley, California by Mr. H. M. JEFFERS. My observations of it were terminated by absence on the eclipse expedition. At various times the brightness of the asteroid was compared with that of small stars in the field with it. These comparisons cannot be used here, but the direct estimates of its magnitude are given in the following table.

1918	M	1918	M	1918	M
Feb. 12	12.7	Mar. 2	13.2	Apr. 4	14.9
16	13.0	7	13.4	9	15½
28	13.5	14	13.8	13	15.0
		16	13.9	16	15.7

On March 23 and 26 it was "very faint in moonlight."

The photograph of February 10 with the 10-inch Bruch lens was measured and the following position obtained:

1918 C. S. T.	α Appt.	δ Appt.	Log $p\Delta$ α	Log $p\Delta$ δ
Feb. 10^d 11^h 57^m	7^h 14^m 8^s.6	+35° 12′ 37″	9.4564	0.2068

The comparison of this with the ephemeris of MR. JEFFERS in *L. O. Bulletin*, No. 309, seems to show that the position is fair.

I find the asteroid on my Bruce plates of 1918 January 14, but it is in the region of poor definition and measures of the position would not be of much value. The approximate place for that date is:

1918 Jan. 14^d 11^h 29^m C. S. T.

1918.0 α 5^h 45^m 22^s , δ + 22° 0′.3

The closely approximate position from the plate of February 9 is:

1918 Feb. 9^d 12^h 32^m C. S. T.

1918.0 α 7^h 10^m 59^s.5 , δ + 35° 30′.7

The observations are given in Central Standard Time, which is 6^h 0^m slow of Greenwich Mean Time. All the visual measures were made with the 40-inch telescope.

Measured Positions of the Asteroid.

1918	Cent. Stan. Time	$\Delta\alpha$	$\Delta\delta$	Comps.	α App.	δ App.	log $p\Delta$ α	log $p\Delta$ δ	Red. to App.		*
	h m s	m s	′ ″		h m s	° ′ ″			s	″	
Feb. 12	11 57 0	−0 19.22	+2 20.9	5 , 7	7 20 56.34	+36 5 22.6	9.4639	0.1875	+3.31	−2.7	1
16	7 36 1	+0 13.96	−1 29.2	5 , 6	7 33 22.29	+36 35 13.5	9.4518*n*	0.1673	+3.33	−3.3	2
16	7 55 38	+0 3.74	+2 53.6	5 , 8	7 33 24.89	+36 35 19.2	9.3927*n*	0.1173	+3.33	−3.3	3
19	11 3 59	+0 7.96	−0 20.4	10 , 4	7 43 17.02	+36 48 52.7	9.2856	0.0453	+3.35	−3.8	4
19	11 20 43	....	−0 18.8	.. 5	....	+36 48 54.3	....	0.0899	.....	−3.8	4
19	11 32 31	+0 11.56	−0 16.9	11 , 4	7 43 20.62	+36 48 56.2	9.4031	0.1206	+3.35	−3.8	4
21	13 50 12	+0 3.57	−0 48.7	4 , 6	7 49 48.01	+36 52 58.3	9.6840	0.4728	+3.59	−4.2	5
28	12 14 0	+0 5.35	−2 2.7	5 , 8	8 10 13.22	+36 42 58.7	9.5453	0.2577	+3.34	−5.0	6
28	12 49 56	+0 9.50	−2 9.3	6 , 3	8 10 17.37	+36 42 52.1	9.6128	0.3483	+3.34	−5.0	6
Mar. 2	7 20 19	−0 4.94	+1 35.9	5 , 8	8 15 17.45	+36 35 17.0	9.1548*n*	0.1703	+3.32	−5.2	7
2	11 13 41	−0 21.93	−0 9.8	5 , 9	8 15 43.11	+36 34 29.4	9.3729	0.1106	+3.32	−5.2	8

Date	Cen. Stan. Time	Δα	Δδ	Comps.	α App.	δ App.	log pΔ α	log pΔ δ	Red. to App.		*
	h m s	m s	′ ″		h m s	° ′ ″			s	″	
7	11 25 39	+0 0.45	+0 39.9	5 , 8	8 29 14.12	+36 3 23.7	9.4362	0.1761	+3.29	−6.0	9
7	12 20 32	+0 6.25	+0 21.9	6 , 4	8 29 19.92	+36 3 5.7	9.5740	0.3139	+3.29	−6.0	9
14	12 24 16	−0 4.63	−1 19.5	6 , 7	8 47 3.22	+35 1 17.1	9.5922	0.3711	+3.23	−6.4	10
14	13 9 59	−0 0.03	−1 40.0	9 , 4	8 47 7.82	+35 0 56.6	9.6571	0.4698	+3.23	−6.4	10
16	8 4 19	+0 4.80	+3 43.3	5 , 8	8 51 28.29	+34 42 23.0	9.1732n	0.1139	+3.21	−6.9	11
16	8 31 48	−0 4.94	. . .	4	8 51 30.76	. . .	8.9395n	. . .	+3.21	. . .	12
16	8 46 10	−0 3.55	−5 4.4	5 , 9	8 51 32.15	+34 42 4.5	8.7404n	0.0792	+3.21	−6.9	12
23	7 31 18	+0 9.69	−0 45.2	5 , 9	9 7 40.99	+33 21 56.9	9.2856n	0.2122	+3.14	−7.5	13
26	10 7 23	−0 1.88	−0 41.2	6 , 8	9 14 34.37	+32 42 45.5	9.2122	0.2201	+3.09	−7.8	14
26	10 17 8	−0 1.02	−0 46.6	4 , 8	9 14 35.23	+32 42 40.1	9.2648	0.2330	+3.09	−7.8	14
28	11 35 33	+0 7.82	+0 50.3	5 , 6	9 19 2.83	+32 15 55.1	9.5302	0.3820	+3.06	−8.0	15
30	7 48 27	−0 3.74	+2 9.1	5 , 9	9 22 59.52	+31 51 27.7	9.1072n	0.2330	+3.03	−8.2	16
30	8 6 39	−0 2.20	+1 58.0	4 , 8	9 23 1.06	+31 51 16.6	8.9494n	0.2175	+3.03	−8.2	16
Apr. 4	10 51 4	−0 16.89	−0 28.7	5 , 8	9 33 38.91	+30 40 55.4	9.4440	0.3674	+3.00	−8.8	17
4	12 9 5	−0 18.22	+1 26.9	5 , 10	9 33 45.42	+30 40 8.7	9.6042	0.4900	+3.00	−8.8	18
9	8 59 4	−0 1.30	−2 36.8	4 , 8	9 43 32.22	+29 30 49.5	8.8751	0.2988	+2.92	−9.0	19
9	9 27 9	+0 0.98	−2 53.4	4 , 6	9 43 34.50	+29 30 32.9	9.1106	0.3160	+2.92	−9.0	19
13	8 6 39	−0 8.47	+3 46.5	5 , 8	9 51 17.00	+28 33 6.0	8.5051n	0.3263	+2.87	−9.4	20
13	10 35 13	+0 3.23	+2 15.1	5 , 6	9 51 28.70	+28 31 34.6	9.4393	0.4216	+2.87	−9.4	20
16	8 9 57	−0 11.52	−1 14.4	7 , 9	9 57 1.99	+27 48 46.0	7.9031n	0.3444	+2.85	−9.7	21
16	8 32 36	−0 9.65	−1 28.0	5 , 8	9 57 3.86	+27 48 32.4	8.6128	0.3483	+2.85	−9.7	21
16	10 20 18	−0 1.29	−2 5.6	5 , 7	9 57 12.22	+27 47 54.8	9.4099	0.4249	+2.85	−9.7	21

In every observation the Δα of the asteroid and the comparison star was measured direct. These measures are given in the table below.

Measured Δα of the Asteroid and Comparison Stars

1918	Δ α cos δ	1918	Δ α cos δ	1918	Δ α cos δ	1918	Δ α cos δ
	″		″		″		″
Feb. 12	−233.2	Mar. 2	− 59.5	Mar. 16	− 43.9	Apr. 4	−235.0
16	+168.2	2	−264.1	23	+121.3	9	− 16.9
16	+ 15.0	7	+ 5.1	26	− 23.4	9	+ 12.8
19	+ 95.7	7	+ 75.8	26	− 12.7	13	−111.7
19	+138.9	14	− 56.8	28	+ 99.2	13	+ 42.5
21	+ 42.9	14	− 0.3	30	− 47.7	16	−152.8
28	+ 64.3	16	+ 59.2	30	− 28.1	16	−127.9
28	+111.1	16	− 61.0	Apr. 4	−217.9	16	− 17.1

Mean Places of Comparative Stars.

*	α 1918.0	δ 1918.0	Authority
	h m s	° ′ ″	
1	7 21 12.26	+36 3 4.1	12 mag. Compared with Lund *A. G. C.* 3848
2	7 33 5.00	+36 36 46.0	12 mag. Compared with Star 3
3	7 33 17.82	+36 32 28.9	13.3 mag. Compared with Lund *A. G. C.* 3939

*	α 1918.0	δ 1918.0	Authority
	h m s	° ′ ″	
4	7 43 5.71	+36 49 16.9	Lund *A. G. C.* 3986
5	7 49 40.85	+36 53 51.2	12½ mag. Compared with Lund *A. G. C.* 4019
6	8 10 4.53	+36 45 6.4	12½ mag. Compared with Lund *A. G. C.* 4159
7	8 15 19.07	+36 33 16.3	12.2 mag. Compared with Lund *A. G. C.* 4204
8	8 16 1.72	+36 34 44.4	Lund *A. G. C.* 4204
9	8 29 10.38	+36 2 49.8	12½ mag. Compared with Lund *A. G. C.* 4283
10	8 47 4.62	+35 2 43.0	12.5 mag. Compared with Lund *A. G. C.* 4398
11	8 51 20.28	+34 38 46.6	14 mag. Compared with Küstner 3948
12	8 51 32.50	+34 37 7.0	Küstner 3948
13	9 7 28.16	+33 22 49.6	11–12 mag. Compared with Leiden *A. G. C.* 3787
14	9 14 33.16	+32 43 34.5	12 mag. Compared with Leiden *A. C. C.* 3818
15	9 18 51.95	+32 15 12.8	13–14 mag. Compared with Leiden *A. G. C.* 3862
16	9 23 0.23	+31 49 26.8	Leiden *A. G. C.* 3873
17	9 33 52.80	+30 41 32.9	13.9 mag. Compared with Leiden *A. G. C.* 3932
18	9 34 0.64	+30 38 50.6	Leiden *A. G. C.* 3932
19	9 43 30.60	+29 33 35.3	12½ mag. Compared with Bonn *A. G. C.* 4343
20	9 51 22.60	+28 29 28.9	12½ mag. Compared with Cambridge (Eng.) *A. G. C.* 5151
21	9 57 10.66	+27 50 10.1	12½ mag. Comp. with Oxford Photograph +28° 29797 and +27° 25332

Measures of Comparative Stars.

Date	Comparison Star — Known Star	Δα cos δ	Δα	Δδ	Comps.
		″	m s	′ ″	
1918 Mar. 16, 1919 Apr. 12	Star (*a*) — Lund *A. G. C.* 3848	......	−1 47.40	+4 36.2	26 tr, 8
1918 Feb. 12, 1919 Apr. 12	Star 1 — Star (*a*)	......	+0 47.78	+1 37.3	20 tr, 6
1918 Feb. 16	Star 2 — Star 3	−153.9	−0 12.78	+4 17.1	5 , 5
16	Star 3 — Lund *A. G. C.* 3939	....	−1 24.86	+3 35.8	6 tr, 4
21	Star 5 — Lund *A. G. C.* 4019	.....	+0 54.16	−3 27.0	12 tr, 4
28	Star 6 — Lund *A. G. C.* 4159	...	+0 35.90	+0 22.8	16 tr, 5
Mar. 2	Star 7 — Lund *A. G. C.* 4204	...	−0 42.65	−0 58.1	16 tr, 4
7	Star 9 — Lund *A. G. C.* 4283	...	+0 48.73	−1 53.8	20 tr, 4
14	Star 10 — Lund *A. G. C.* 4398	.	−0 41.91	−0 37.9	14 tr, 4
16	Star 11 — Küstner *A. G. C.* 3948	−150.8	−0 12.22	+1 39.6	4 , 4
23	Star 13 — Leiden *A. G. C.* 3787	....	+0 36.88	−2 24.6	22 tr, 6
26	Star 14 — Leiden *A. G. C.* 3818	....	+0 36.66	+3 49.6	18 tr, 7
28, 30	Star 15 — Leiden *A. G. C.* 3862		−2 5.89	+0 20.1	14 tr, 5
Apr. 4	Star 17 — Leiden *A. G. C.* 3932	−101.2	−0 7.84	+2 42.3	5 , 5
9	Star (*b*) — Bonn *A. G. C.* 4343	......	−0 52.01	−0 27.5	12 tr, 4
9	Star 19 — Star (*b*)	− 15.6	−0 1.20	−4 0.3	4 , 4
13	Star 20 — Camb. (Eng.) *A.G.C.* 5151	......	−0 50.17	+0 13.7	20 tr, 4
16	Star 21 — Oxford Phot. +28° 29797 and +27° 25332	......	+0 41.68	−2 7.9	20 tr, 4

The positions of the two step stars, (a) and (b), of February 12 and April 9, 1918, are:

Star (a) (11^M) 1918.0 α $7^h 20^m 24^s.48$ δ $+36° \; 1' \; 27''.5$
Star (b) ($11\frac{1}{2}$) $9 \; 43 \; 31 .80$ $+29 \; 37 \; 35 .6$

As a check, on April 4 the stars Leiden *A. G. C.* 3932 and 3933 were measured:

$\Delta\alpha \cos\delta$ $116''.73$ (5) $= \Delta\alpha$ $9^s.04$, $\Delta\delta$ $6''.34$ (5)

Comparing these differences with the catalogue differences we get:

$$O - Cat. \quad +0^s.08 \quad -0''.2$$

Yerkes Observatory, Williams Bay, Wisconsin.
April 14, 1919.

THE COMPANION OF *SIRIUS*.

By E. E. BARNARD.

The following observations of the companion of *Sirius* are a continuation of those printed in *Astronomical Journal*, XXX, p. 182.

Date		P. A.	Dist.	H. A.	Remarks
		°	"	h m	
1917.860	Nov. 10	70.89	10.85	W 1 0	Seeing poor.
1918.022	Jan. 8	68.82	10.96	0 0	V. difficult. Seeing bad.
.052	19	71.39	11.04	E 0 30	Well seen.
.080	29	71.01	10.79	W 1 0	Seeing = 1. Observation uncertain.
.118	Feb. 12	70.04	10.95	E 0 30	Well seen.
.129	16	69.23	11.04	W 0 30	Very difficult.
.167	Mar. 2	71.02	11.05	0 0	Well seen though badly blurred. Seeing = 2.
.205	16	72.43	11.24	E 0 30	Difficult. Seeing = 2.
1918.079		70.73	10.99		
1918.904	Nov. 26	69.30	....	E 0 30	Seeing too poor for distance.
.928	Dec. 5	69.98	11.07	E 0 30	Well seen at distance meas. Angles diff.
.961	17	70.91	10.95	E 1 0	Observation fairly good.
1919.049	Jan. 18	69.38	10.95	E 0 10	Difficult but obs. good. Seeing = 2.
.068	25	69.70	11.04	W 0 10	Seeing 2 – 3.
.076	28	68.29	11.12	E 0 45	Fairly well seen but image blurring.
.087	Feb. 1	69.32	11.04	E 0 40	Observation fairly good. Seeing = 2.
.095	4	69.51	11.27	E 0 25	Difficult.
.114	11	70.83	10.90	E 0 50	Difficult.
.125	15	69.40	11.18	E 0 25	Well seen. Seeing = 3.
.134	18	68.71	11.08	W 0 10	Quite bright and steady.
.166	Mar. 1	68.81	11.19	E 0 10	Seeing poor.
.210	18	69.75	10.95	E 0 10	Well seen.
.249	Apr. 1	68.35	10.93	W 0 40	Fairly well seen.
.265	7	70.29	11.05	W 1 0	Seen with difficulty.
1919.095		69.50	11.05		

Yerkes Observatory, Williams Bay, Wisconsin.
April 15, 1919.

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ON A SIMPLIFICATION OF LUIZET'S METHOD FOR OBTAINING THE ORBIT OF A CEPHEID VARIABLE FROM ITS LIGHT CURVE,

BY F. HENROTEAU.

If we suppose the Cepheids to be binary systems, the period P, the eccentricity e, the time of periastron passage T and the longitude of periastron $\bar{\omega}$ (which LUIZET calls λ) can be derived from their light curves, by a method which has been elegantly devised by DR. LUIZET of the observatory of Lyons*.

LUIZET's method can be greatly simplified and reduced merely to a direct reading of the above elements from the Allegheny Tables of Anomalies†.

We shall assume with LUIZET —

1. That the time of maximum velocity of recession of the star is the same as that of minimum brightness;

2. That the time of maximum velocity of approach is the same as that of maximum brightness:

3. That DUNCAN's working hypothesis to explain the variation of brightness is correct, and consequently that it can be proved that if M is the maximum brightness and m the minimum brightness of the star, and if the brightness at periastron is $M - E$, the brightness at apastron will be $m + E$.

These three assumptions are only approximate, as one can see for instance from the work on the radial velocity of δ *Cephei* by DR. MOORE at the Lick Observatory, where he compares the velocity curve with the light curve, and also from other studies. Besides, subsequent work by different observers has made the binary theory of Cepheids doubtful, although many still maintain it.

It would nevertheless be very important to obtain the orbits of all the Cepheids by using LUIZET's method simplified as below.

Annales de l'Université de Lyon. Nouvelle série. Fascicule 33-1912. Les Cepheides considérées comme étoiles doubles.

†*Publications of the Allegheny Observatory, 2*, p. 155, 1912.

First, we transform the light curve or curve of variation of magnitude into a curve of *relative* brightness by the well known formula:

$$\Delta m = -2.5 \log \frac{I}{I_0}$$

What we now want to obtain from this curve of brightness is:

1. The time that the star has its maximum radial velocity of approach (time of maximum brightness):

2. The time that the star has its maximum velocity of recession (time of minimum brightness):

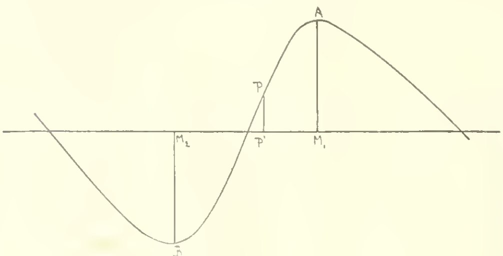
3. The time of periastron passage, which from the consideration above can be easily obtained from the curve of brightness in the following manner. Lay a piece of semi-transparent paper over the curve of brightness and copy on this the curve and the mean axis (or line of middle brightness), marking also the points O, $\frac{P}{2}$, P and $\frac{3P}{2}$. Shifting this copy bodily along the mean axis for a distance $\frac{P}{2}$ or half the period, rotate the copy 180° above the mean axis; that is, turn the copy face downward on the original curve, keeping the mean axis in coincidence, and bring the point O or P of the copy over the point $\frac{P}{2}$ of the curve. The curves will then cut one another in general in four points, of which two will be the points of periastron and apastron. The periastron point will be that situated on the branch of the curve for which the variation of light is the most rapid*.

*This procedure resembles the one used by SCHWARZSCHILD for determining an orbit from radial velocities.

Now, when on the axis of time we know the abscissæ of the three above points, these abscissæ are the same as for the radial velocity curve, whose equation is (taking the mean axis as the axis of abscissæ)

(2) $$y = K \cos (v + \bar{\omega})$$

where ω is the longitude of periastron, $\frac{v}{1}$ the true anomaly and K the semi-amplitude of velocity variation. Now if P' is the foot of the ordinate of the periastron point in fig. 1 and if we call $\mu = \frac{360°}{P}$, the mean motion, then $\mu\ P'M_1 = M_x$ will be the mean anomaly of the point A and $-\mu\ P'M_2 = -M_y$ will be the mean anomaly of the point B. If v_x and $-v_y$ are their corresponding true anomalies, it is easy



to see from equation (2) that $v_x + v_y = 180°$. At A we have $y = K$ or $\cos (v + \bar{\omega}) = 1$, hence $v_x + \bar{\omega} = 360°$ (3). At B we have $y = -K$ or $\cos (v + \bar{\omega}) = -1$, hence $-v_y + \bar{\omega} = 180°$ (4). If we subtract (4) from (3) we have $v_x + v_y = 180°$ (5).

Having measured $P'M_2$ and $P'M_1$ on the curve, we multiply them by μ and obtain M_x and M_y. We then take these last quantities in the Allegheny Tables and find out in which column the corresponding v_x and v_y have a sum equal to 180°. The eccentricity read at the top of the column will be the eccentricity of the orbit. Moreover since $v_x + \bar{\omega} = 360°$ the longitude of periastron will be $\bar{\omega} = 360° - v_x$.

We then have all the elements in a very short time, P and T from the light curve and the position of the periastron point without computation, then e and $\bar{\omega}$ from the Allegheny Tables as indicated above and also without computation.

As an example, the preceeding method was applied to the light curve of *δ Cephei* obtained by STEBBINS*. We transform the light curve into a curve of brightness, then we find $M_x = 58°.4$, $M_y = 40°.2$, we find that in the column for $e = 0.37$, $v_x = 101°.6$ and $v_y = 78°.4$ so that $v_x + v_y = 180°$ and we see immediately that the elements of the orbit of *δ Cephei* are

$$P = 5.366$$
$$e = 0.37$$
$$\lambda = 78°.4$$
$$T = 4^d.77$$

It is interesting to compare these elements with those obtained spectroscopically by BELOPOLSKI†.

$$P = 5.366$$
$$e = 0.36$$
$$\lambda = 82°.8$$
$$T = 4^d.99$$

These two sets of elements are in good agreement.

The method could be applied readily to many other Cepheids and would give an accuracy comparable with that of longer methods.

The theory that Cepheids are not spectroscopic binaries seems to have now more and more arguments in its favor although it has not been established definitively. A study of the light curves of a great many Cepheids and the deduction from them of the elements of their possible orbits would throw some light on the subject. It seems that, at present, the theories concerning Cepheids are far more advanced than the data warrant and it is a fact that very few light curves of Cepheids have been well determined.

Allegheny Observatory,
1919, February 17.

* *Astrophysical Journal*, p. 188, 1908.

† *Pulkovo Mitteilungen*, III, No. 28.

OBSERVATIONS OF COMET 1918 *d* (*SCHORR*),

By E. E. BARNARD.

The comet was faint and diffused with no special condensation and hence the measures of it will lack the definiteness of those of a more condensed comet.

The times given for the observations are Central Standard Time, 6ʰ slow of Greenwich Mean Time.

Measured Positions of the Comet.

1918	Cent. Stan. Time	Δ α	Δ δ	Comp.	α Appt.	δ Appt	Log. p Δ α	Log. p Δ δ	Red to Appt. α	Red to Appt. δ	*
	h m s	m s	′ ″		h m s	° ′ ″			s	″	
Nov. 30	9 21 59	+0 12.88	−0 13.3	5 , 9	4 7 5.18	+11 49 43.9	9.3541*n*	0.6656	+5.14	+12.5	1
30	10 31 30	+0 11.36	−0 5.9	4 , 9	4 7 3.66	+11 49 51.3	9.0492*n*	0.6522	+5.44	+12.5	1
30	11 55 3	+0 8.17	+0 1.6	4 , 8	4 7 0.47	+11 49 58.8	8.7782	0.6522	+5.44	+12.5	1
Dec. 3	9 27 52	−0 17.07	+3 15.0	5 , 6	4 5 6.59	+11 57 44.9	9.2833*n*	0.6599	+5.43	+12.5	2
5	10 49 40	−0 0.22	+0 33.7	4 , 7	4 3 49.57	+12 4 3.6	8.3617*n*	0.6474	+5.50	+12.8	3
5	11 53 17	−0 1.88	+0 38.7	7 , 4	4 3 47.91	+12 4 8.6	9.0086	0.6493	+5.50	+12.8	3
7	11 28 9	+0 3.80	+1 47.8	5 , 7	4 2 37.39	+12 10 54.4	8.7482	0.6461	+5.52	+12.9	4
7	12 14 55	+0 2.23	+1 53.8	4 , 9	4 2 35.82	+12 11 0.4	9.1931	0.6561	+5.52	+12.9	4

Measured Δα of Comet and Comparison Stars.

1918 Nov. 30		Δα cos δ	+188.97
30			+156.74
30			+119.89
Dec. 3			−250.53
5			− 3.20
5			− 27.62
7			+ 55.66
7			+ 32.75

Mean Places of Comparison Stars.

*	α 1918.0	δ 1918.0	Authority
	h m s	° ′ ″	
1	4 6 46.86	+11 49 44.7	13 mag. Compared with Leipzig *A. G. C.* 1221
2	4 5 18.23	+11 54 17.4	12 mag. Compared with Leipzig *A. G. C.* 1221
3	4 3 44.29	+12 3 17.1	12½ mag. Compared with Leipzig *A. G. C.* 1202
4	4 2 28.07	+12 8 53.7	12.8 mag. Compared with Leipzig *A. G. C.* 1209

Measures of Comparison Stars.

Date	Comparison Star — Known Star	Δ α	Δ δ	Comps.
		m s	′ ″	
1918 Nov. 30	Star 1 — Leipzig *A. G. C.* 1221	+0 59.09	−1 51.3	18 tr, 4
Dec. 3	Star 2 — Leipzig *A. G. C.* 1221	−0 29.54	+2 41.4	14 tr, 5
5	Star 3 — Leipzig *A. G. C.* 1202	+1 6.09	+0 19.9	20 tr, 4
7	Star 4 — Leipzig *A. G. C.* 1209	−1 28.60	+0 57.4	14 tr, 4

Notes on the Comet

1918 Nov. 30. The comet was 15 magnitude; diameter 1′. Difficult in bad sky.

Dec. 3. The comet was faint, 15 or 15½ magnitude; 1′ in diameter and very dull looking; very little condensation.

Dec. 5. Comet 16 magnitude.

Dec. 7. Excessively faint in bad sky.

Yerkes Observatory, Williams Bay, Wisconsin
April 15, 1919.

OBSERVATIONS OF ASTEROIDS,

MADE WITH THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY,

By GEORGE H. PETERS.

[Communicated by Rear Admiral T. B. Howard, U. S. Navy, Superintendent.]

Name	Mag.	Date, 1917	G. M. T.	Astrographic 1917.0 α	Astrographic 1917.0 δ
			h m	h m s	° ′ ″
(242) *Kriemhild*	13.2	Aug. 10	16 22.0	21 11 09.10	− 0 10 27.6
(485) *Genua*	12.2	Aug. 10	16 22.0	21 02 12.38	+ 0 45 35.8
(242) *Kriemhild*	13.2	Aug. 13	16 15.7	21 08 50.94	− 0 24 36.6
(485) *Genua*	12.2	Aug. 13	16 15.7	20 59 50.94	+ 0 28 34.4
(485) *Genua*	12.2	Aug. 15	17 30.2	20 58 14.92	+ 0 16 21.4
(792) [*1907 ZC*]	13.5	Aug. 17	17 03.0	22 08 20.22	+ 1 15 23.6
(483) *Seppina*	12.2	Aug. 18	16 02.6	22 14 45.62	+ 0 36 30.5
(792) [*1907 ZC*]	13.5	Aug. 18	17 28.1	22 07 27.72	+ 1 12 19.9
(483) *Seppina*	12.2	Aug. 20	18 05.5	22 13 28.00	+ 0 20 19.9
(88) *Thisbe*	10.0	Sept. 13	16 57.5	23 14 52.55	+ 4 30 48.0
(88) *Thisbe*	10.0	Sept. 17	15 36.6	23 11 40.83	+ 4 11 30.0
(419) *Aurelia*	10.8	Sept. 19	16 59.2	0 26 25.46	+ 8 02 39.0
(419) *Aurelia*	10.8	Sept. 22	16 22.0	0 23 48.56	+ 7 42 29.7
(24) *Themis*	11.1	Oct. 11	15 29.8	1 06 21.98	+ 6 40 51.6
(49) *Pales*	9.6	Oct. 13	15 49.1	0 38 45.48	+10 02 35.6
(110) *Lydia*	10.2	Oct. 13	17 08.1	1 39 53.48	+ 4 29 16.6
(24) *Themis*	11.1	Oct. 14	15 53.7	1 04 05.50	+ 6 27 29.0
(110) *Lydia*	10.2	Oct. 15	15 16.2	1 38 09.72	+ 4 23 20.4
(29) *Amphitrite*	8.7	Oct. 16	16 24.8	1 41 24.20	+16 09 50.8
(393) *Lampetia*	10.4	Oct. 16	16 24.8	1 54 26.83	+14 42 10.6
(29) *Amphitrite*	8.7	Oct. 17	15 54.9	1 40 25.86	+16 07 22.4
(393) *Lampetia*	10.4	Oct. 17	15 54.9	1 53 36.76	+14 30 37.4
(70) *Panopaea*	10.8	Oct. 17	16 36.2	2 20 19.39	+ 7 56 49.7
(70) *Panopaea*	10.8	Oct. 21	16 21.8	2 16 10.64	+ 7 54 03.4
(344) *Desiderata*	11.7	Nov. 6	14 50.7	2 13 25.20	+ 6 55 35.2
(344) *Desiderata*	11.7	Nov. 6	15 58.7	2 13 21.95	+ 6 55 35.6
(519) *Sylvania*	11.3	Nov. 7	15 16.2	2 27 25.69	+13 12 08.6
(138) *Tolosa*	11.7	Nov. 7	15 16.2	2 35 34.93	+14 01 23.3
(149) *Medusa*	11.6	Nov. 7	16 20.2	3 15 38.80	+16 20 48.6
(85) *Io*	10.4	Nov. 8	14 32.3	2 03 17.65	+ 7 31 17.8
(344) *Desiderata*	11.7	Nov. 8	14 32.3	2 11 13.80	+ 6 58 52.2
(519) *Sylvania*	11.3	Nov. 8	15 22.8	2 26 25.22	+13 12 49.6
(138) *Tolosa*	11.7	Nov. 8	15 22.8	2 34 33.56	+13 58 13.4
(149) *Medusa*	11.6	Nov. 8	16 16.8	3 14 34.56	+16 16 16.4
(85) *Io*	10.4	Nov. 9	15 07.3	2 02 34.14	+ 7 22 28.0
(25) *Phocaea*	10.5	Nov. 16	16 17.3	2 37 54.36	+ 7 30 19.6
1917 *W 15*	12.0	Nov. 16	16 17.3	2 49 30.94	+ 9 21 01.6
(25) *Phocaea*	10.5	Nov. 17	15 05.6	2 37 07.18	+ 7 18 37.0
1917 *W 15*	12.0	Nov. 17	15 05.6	2 48 35.70	+ 9 25 19.4
1917 *W 15*	12.0	Nov. 19	13 58.3	2 46 44.24	+ 9 34 26.4
1917 *W 15*	12.0	Dec. 1	14 20.4	2 36 54.84	+10 36 06.1
1917 *W 15*	12.0	Dec. 5	14 28.2	2 34 23.43	+10 58 52.1
1917 *W 15*	12.0	Dec. 10	14 08.2	2 31 51.54	+11 28 37.8
1917 *W 15*	12.0	Dec. 15	14 07.9	2 30 01.41	+12 00 07.2

The above asteroid observations, and those published by me in *Astronomical Journals* Nos. 679, 680, 690, 702, 716, 719, 729 and 732 are to be defined as astrographic positions. *A. G.* stars are usually employed for comparison stars, reduced to the beginning of the year by applying precession secular variation, and when known, proper-motion, to the catalogue places.

Three comparison stars are always used, but sometimes more if available, within a reasonable distance, and properly situated with respect to the asteroid.

These published positions are the *means* of results obtained from the comparison stars, and are published by me for the first time to the same number of places as given in the *A. G.* catalogues. The probable error of plate measurement with the Stackpole engine is known to be small, especially for the fainter stars, which are always employed when possible. By the use of several comparison stars the accidental error of the catalogue places is reduced and the computed positions of the asteroids are more accurate than the maximum errors of the catalogue places of the comparison stars.

For convenience of those discussing observations it would seem best to adopt arbitrary equinoxes. The most convenient epoch for the present would appear to be 1925.0, which has been selected, by the Rechen-Institut for minor planets. Pending some general agreement among computers and observers regarding this matter, I shall continue to use the beginning of the year of observation.

The asteroid 1917 *W* **15** was discovered by the writer upon the plate with (25) *Phocæa* Nov. 16, 1917. A series of observations was immediately undertaken for deriving elements both with the photographic telescope, and 26-inch equatorial. Elements were published in *A. J.* 729, and "Second Elements and Ephemeris," in *A. J.* 739, by Bower and Wylie.

From the "Second Elements," Mr. Bower computed an ephemeris for 1917 *W* **15** for the opposition 1919. Photographic observations on Jan. 24, 27 and 31, 1919, which have been reduced, show corrections to the ephemeris $\Delta\alpha - 19^s$, $\Delta\delta - 0'.2$.

In response to the request contained in *A. J.* 739, Miss Harwood of the Maria Mitchell Observatory, Nantucket, Mass., who had independently found this object on six plates, sent them to the Naval Observatory, where they were measured and reduced by Mr. Bower. In case the asteroid 1917 *W* **15** proves to be new the name *Washingtonia* was suggested in *A. J.* 729.

THE POSITION AND PROPER-MOTION OF *NOVA AQUILÆ* NO. 3,

By ROBERT TRUMPLER.

The material used for a determination of the proper-motion of *Nova Aquilæ* No. 3 consists of the following photographic measures:

1. Two measures of the *Nova* in the *Astrographic Catalogue*, Zone Algiers, Vol. V:

No. 4, plate 341, center at $18^h\ 48^m$, 0°, 1892 August 13.

No. 108, plate 1003, center at $18^h\ 40^m$, 0°, 1895 June 26.

2. The *Nova* was found as a faint but well measurable image on two plates taken at the Allegheny Observatory with the 3-inch doublet camera, 1914 June 1 and June 24.

3. Shortly after the outburst the *Nova* was put on the parallax program of the Allegheny Observatory, and one of the plates taken for this purpose with the 30-inch refractor 1918 June 15, was measured.

The *relative proper-motion* of the *Nova* was derived from a comparison of the last plate with the *Astrographic Catalogue*, for which the time interval is twenty-five years. Ten reference stars were selected in the immediate neighborhood of the *Nova*, their brightness ranging between photographic magnitude 10.5 and 12.5, and being in the mean equal to the *Nova* before the outburst. The annual proper-motion of the *Nova* relative to these ten faint comparison stars was found to be

$$\mu_\alpha = +0^s.0003 \quad , \quad \mu_\delta = -0''.004$$

The motion of the *Nova* therefore does not differ appreciably from the mean motion of the comparison stars.

The *photographic magnitudes* of the reference stars were determined from a comparison with one of the Harvard Standard Regions (H. A. Vol. LXXI). By means of the reference stars the magnitude estimates for the *Nova* on the different plates have been reduced on the Harvard system. The four plates taken prior to the outburst gave the following results for the photographic magnitude of the *Nova*:

Astrogr. Catalogue:	1892	Aug. 13	11.1
	1895	June 26	10.8
3-inch Doublet:	1914	June 1	11.5
	1914	June 24	11.5

An attempt has further been made to determine the *position* and the *absolute proper-motion* of the *Nova* in the system of Boss' *Preliminary General Catalogue* (*P. G. C.*). For this purpose a set of seven brighter comparison stars between the photographic magnitudes 6.2 and 10.2, symmetrically distributed around the *Nova*, were selected. All the available catalogue positions of these stars were reduced to Boss' system and used to determine the mean positions and proper-motions of these stars by least-squares solutions. The results are given in Table 1 in a form corresponding exactly to that of the *P. G. C.*

TABLE 1

POSITIONS AND PROPER-MOTIONS OF COMPARISON STARS

B. D.	Mag.	R. A. and Decl. 1900.0	Epoch	Annual Variation	Secular Variation	Proper-Motion	Probable Errors α, δ Epoch	Probable Errors 100μ
+0° 4018	8.9	18h 41m 24s.326	1907.3	+3s.0537	−s.0003	−s.0011	±″.13	±″.90
		+0° 45′ 49″.90	1908.2	+3″.579	+″.437	−″.024	± .14	± .94
+0° 4023	8.5	18h 43m 34s.565	1908.0	+3s.0737	−s.0005	+s.0008	± .13	± .91
		+0° 24′ 44″.28	1909.0	+3″.756	+″.438	−″.033	± .13	± .99
+0° 4026	8.5	18h 43m 55s.148	1907.6	+3s.0682	−s.0005	+s.0003	± .13	± .87
		+0° 11′ 33″.28	1908.2	+3″.823	+″.438	+″.004	± .13	± .86
+0° 4027	6.5	18h 44m 31s.480	1892.0	+3s.0548	−s.0005	−s.0010	± .08	± .39
		+0° 43′ 22″.71	1895.1	+3″.835	+″.436	−″.035	± .08	± .43
+0° 4028	9.0	18h 44m 49s.459	1907.7	+3s.0641	−s.0005	+s.0014	± .13	± .88
		+0° 25′ 23″.30	1908.8	+3″.872	+″.437	−″.024	± .13	± .96
+0° 4033	8.6	18h 45m 53s.927	1904.1	+3s.0690	−s.0006	−s.0004	± .11	± .77
		+0° 7′ 45″.87	1904.0	+3″.995	+″.438	+″.006	± .11	± .75
+0° 4035	7.9	18h 46m 10s.304	1904.6	+3s.0576	−s.0005	+s.0016	± .12	± .67
		+0° 42′ 57″.63	1901.8	+4″.003	+″.436	−″.008	± .12	± .54

By means of these seven reference stars the photographic measures of the *Nova* could be reduced to Boss' system, as given in Table 2.

TABLE 2

OBSERVATIONS OF *Nova Aquilæ* NO. 3 REDUCED TO BOSS' SYSTEM

	System Corr.		R. A. 1900.0	Wt.	Decl. 1900.0	Wt.	Epoch −1900	O - C	
Astrogr. Cat. pl. 341	−s.038	+″.02	18h 43m 48s.383	2.0	+0° 28′ 20″.59	3.0	− 7.4	s.000	−″.17
1003	− .036	+ .11	.374	1.5	.92	2.5	− 5.5	− .008	+ .22
2 Doublet plates	− .034	− .52	.395	3.5	.36	4.0	+14.5	+ .018	+ .01
30″ refractor plate	− .034	− .52	.368	8.0	.27	11.0	+18.5	− .007	− .01

The four positions with the weights indicated in Table 2 gave by least-squares solutions the following *mean position and proper-motion of the Nova for epoch and equinox 1900.0 in the P. G. C. system.*

Position	Epoch	Annual and Secular Variation		Proper-Motion	Prob. E. Epoch	Prob. E. 100μ
18h 43m 48s.381	1911.8	+3s.0612	−0s.0005	−0s.0003	±0″.08	±0″.77
+0° 28′ 20″.62	1911.1	+3″.790	+0″.436	−0″.018	±0″.07	±0″.63

These data are strictly comparable to those of Boss' catalogue and their form will easily permit improvement by additional observations according to the method described on p. xxxiii of the *P. G. C.*

Expressed in distance and position-angle the centennial proper-motion of the *Nova* is

1″.85 in position-angle 194°

The position-angle of the antapex of the *Sun's* motion at the *Nova* is 164°. On the supposition that the component of the motion of the *Nova* in this direction is principally a reflex of the *Sun's* motion, the parallax of the *Nova* would be: $\pi = +0''.006$.

Before its outburst the *Nova* was a star of about the 11th magnitude with a centennial proper-motion of 1″.85. VAN RHIJN's tables (*Ap. J.* 43, p. 36) of the mean parallaxes of stars of given magnitude and proper-motion would give for such a star a hypothetical parallax of: $\pi = +0''.003$.

We may therefore say that *the proper-motion of the Nova indicates a parallax of the order of 0″.005* or a distance of the order of 650 light years.

At a distance corresponding to a parallax of 0″.1, the absolute photographic magnitude of the *Nova* would then be 5.0 before the outburst and −7 to −8 at maximum, or the *Nova* would have increased from a star of about the same luminosity as the *Sun* to one a hundred thousand times more luminous.

A more complete account of this determination of the position and proper-motion of the *Nova* will be given in the Publications of the Allegheny Observatory.

STELLAR PARALLAXES,

DERIVED FROM PHOTOGRAPHS MADE WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY.,

By G. VAN BIESBROECK and Mrs. HANNAH STEELE PETTIT.

The present list of determinations of parallax summarizes the results that have been obtained since Part 1 of Vol. IV of the *Publications* of the Yerkes Observatory was issued. The details of the present series will appear soon as Part 3 of the same volume.

There are 56 parallaxes measured in this list, but some of them refer to the two components of double stars, so that only 50 different fields have been used.

The columns of the table (which is arranged like that in *Astronomical Journal* No. 697) require no explanation except the one headed μ_α. This gives the values obtained for the proper motions in right ascension as deduced along with the parallaxes. The parallaxes have been measured in right ascension only.

Star	α_{1900}	δ_{1900}	*B. D.* No.	Mag. and Spectrum	Relative Parallax	Probable Error	No. of Plates	No. Comp. Stars	μ_α	Mean Mag. of Comp. Stars
	h m	° ′	°		″	″			s	M
HUBBLE's p. m. star	0 45	+57 45	....	11.5 ..	+0.056	±.008	11	5	+0.193	11
48 ω *Andromedæ*	1 22	+44 53	+44 307	5.0 *F5*	+ .001	.016	10	3	+ .038	10½
γ *Ceti*	2 38	+ 2 49	+ 2 422	3.6 *A*	+ .045	.005	15	3	− .010	10½
ι *Persei*	3 2	+49 14	+49 857	4.2 *G*	+ .064	.015	9	6	+ .128	9½
W.B. 3h 167	3 11	+30 40	+30 516	9.2 ..	+ .029	.010	18	4	+ .011	10½
A.G. Berl. B 1231	3 46	+22 23	+22 583	8	+ .035	.008	11	5	+ .014	11
Gr. C. 745	3 48	+75 53	+75 154	8.2 ..	+ .048	.006	14	4	+ .087	10
Aldebaran	4 30	+16 18	+16 629	1.1 *K5*	+ .047	.010	19	4	+ .006	10
β *Tauri*	5 20	+28 31	+28 795	1.8 *B8*	+ .005	.011	15	5	+ .001	10
δ *Aurigæ*	5 51	+54 17	+54 970	3.9 *K*	+ .018	.013	12	4	+ .012	10½
A.G. Cambr. 2935	6 0	+26 34	+26 1067	8.9 ..	+ .015	.006	14	4	− .014	9½
Oxf. ph. 25° 21321	6 10	+25 15	+25 1188	9.2 ..	+ .048	.009	10	5	+ .006	10½
B.G.C. 3499 *A*	6 32	+12 14	+12 1219	7.9 ..	+ .014	.015	12	5	− .006	10½
B.G.C. 3499 *C*	....	....	+12 1222	8.5 ..	− .025	.016	12	5	− .093	10½
Castor A	7 28	+32 6	+32 1581	2.0 *A*	+ .063	.008	17	5	− .017	10
Castor B	....	......	....	2.9 *A*	+ .053	.010	17	5	− .012	10
Procyon	7 34	+ 5 29	+ 5 1739	0.5 *F5*	+ .307	.009	15	5	− .046	10
WB 7h 1029	7 38	+39 49	+39 2001	7 ..	+ .021	.010	12	5	+ .001	11
ζ *Cancri AB*	8 6	+17 57	+18 1867	4.7 *F*	+ .057	.010	16	5	+ .005	10
ζ *Cancri C*	....	......	....	6.1 *F*	+ .077	.010	16	5	+ .011	10
B.D. 67° 552	8 27	+67 38	+67 552	9.3 ..	+ .106	.009	11	3	− .178	11½
Lal. 19022	9 37	+43 10	+43 1958	8 ..	+ .067	.008	15	5	+ .091	11
Lal. 19229	9 43	+14 14	+14 2151	8 ..	+ .006	.015	12	4	+ .027	11½
7 *Sextantis*	9 47	+ 2 55	+ 3 2280	6.2 1*A*	+ .057	.008	11	4	− .011	10
Lal. 21185	10 58	+36 38	+36 2147	7.5 ..	+ .382	.011	9	4	− .045	11

Star	α_{1900}	δ_{1900}	*B. D* No.	Mag. and Spectrum	Relative Parallax	Probable Error	No. of Plates	No. Comp. Stars	μ_α	Mean Mag. of Comp Stars
	h m	°	°		″	″			s	M
B.D. 28° 2078	12 1	+28 3	+28 2078	9.1	+ .017	±.022	14	3	−0.028	10
δ *Corvi*	12 25	−15 58	−15 3482	3.0 *A*	+ .020	.005	15	3	− .010	9
β 612	13 35	+11 15	+11 2589	5.5 *A*	+ .019	.008	14	5	− .006	11
Σ 1835 *A*	14 18	+ 8 54	+ 9 2882	5.1 *A*	+ .012	.012	15	4	− .002	9½
Σ 1835 *BC*	. .	. . .	. . .	6.6	+ .016	.015	12	4	− .003	9½
A.G. Cambr. 7086	15 3	+25 18	+25 2874	9.2	+ .079	.008	20	4	− .061	10½
γ *Coronæ*	15 39	+26 37	+26 2722	3.8 *A*	− .007	.012	12	4	− .009	10
W.B. 16h 400	16 24	+ 3 29	+ 3 3203	9	+ .027	.015	11	3	− .001	10½
ζ *Herculis*	16 38	+31 47	+31 2884	2.8 *G*	+ .095	.010	18	4	− .041	9½
41 *Herculis A*	16 39	+ 6 17	+ 6 3288	7	+ .011	.010	13	3	− .015	10½
41 *Herculis B*	. . .	. . .	. . .	10	+ .014	.007	12	3	− .014	10½
B.G.C. 7783	16 48	+28 50	+28 2624	7	+ .021	.008	20	3	+ .006	9½
Lal. 31055	17 0	− 4 54	− 4 4225	7.5	+ .050	.012	9	4	. . . .	11
77 *Herculis*	17 24	+48 21	+48 2517	5.8 *A*	+ .009	.006	10	5	.000	10
B.G.C. 8038	17 25	− 0 59	− 0 3300	5.3 *G*	+ .067	.015	11	5	− .007	10½
26 *Draconis*	17 34	+61 57	+61 1678	5.3 *F*	+ .107	.010	10	4	+ .036	10½
Barnard's p. m. star	17 53	+ 4 25	. . .	9.7 *M*	+ .509	.006	17	4	− .044	10
Vega	18 34	+38 41	+38 3238	0.1 *A*1	+ .114	.010	17	6	+ .016	10
27 *b*¹ *Cygni*	20 3	+35 42	+35 3959	5.5 *K*	+ .045	.007	14	6	− .019	10½
β *Delphini*	20 33	+14 15	+14 4369	3.7 *F*5	+ .043	.006	10	6	+ .008	10½
Lal. 40728	20 56	+39 52	+39 4400	6.9	+ .027	.011	17	4	+ .019	10½
Pots. ph. Pl. 1214, No. 608	20 56	+39 41	. . .	10	+ .081	.009	15	4	+ .067	10½
Lal. 40844	21 0	+ 6 41	+ 6 4741	8.4	+ .033	.014	19	4	+ .005	10
1 *Pegasi*	21 17	+19 23	+19 4691	4.3 *K*	+ .012	.012	9	4	+ .005	11
71 *g Cygni*	21 26	+46 6	+45 3558	5.3 *K*	+ .013	.008	17	4	+ .004	9½
B.D. 53° 2911	22 28	+53 16	+53 2911	10	+ .027	.012	10	3	+ .153	10½
σ *Pegasi*	22 47	+ 9 18	+ 9 5122	5.3 *F*	+ .043	.009	13	5	+ .033	10
2 *Andromedæ*	22 58	+42 13	+41 4665	5.1 *A*2	− .025	.013	13	4	+ .006	10
β 80	23 14	+ 4 52	+ 4 4994	8.0	− .001	.009	13	3	+ .032	11
Mü. 32805	23 45	+ 2 19	+ 2 4723	8.5	+ .036	.009	14	5	+ .029	10

CORRECTION TO *PRELIMINARY GENERAL CATALOGUE*,

By BENJAMIN BOSS.

My attention was called by Professor Hough to an evident error in the right ascension of *P.G.C.* 4061. On examination of the computation sheets the error was found to be due to the inadvertant comparison of a 1900 position with the seconds of the 1920 position given by the provisional ephemeris. The amended position is:

P.G.C. 4061	A.V.	S.V.	μ		
$15^h\ 52^m\ 41^s.486$	$+4^s.0709$	$+^s.0303$	$-.0045$	$''.508$	$\Delta\mu' = -1$

CONTENTS.

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THE

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No. 753

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MEASURES OF DOUBLE STARS DISCOVERED SINCE 1905,

MADE WITH THE 28-INCH REFRACTOR OF THE ROYAL OBSERVATORY, GREENWICH,

BY ROBERT JONCKHEERE.

This series of measures is independent of that started in *A. J.* 721 and 735, the present observations being solely of stars selected from my new Catalogue of Double Stars (*R. A. S. Memoirs*, Vol. LXI).

All the measures were made with the Greenwich 28-inch refractor. I must again express my gratitude to the *Astronomer Royal* for allowing me to publish these results.

For the sake of uniformity, I have followed the plan adopted by MR. C. P. OLIVIER in *A. J.* 733 and have bracketed the reference number to the above catalogue in order to avoid confusion with BURNHAM's catalogue numbers. As the coördinates of these stars are given for 1920 in the reference catalogue, these figures are not repeated here.

With regard to my measured distances, I do not think that the residuals OLIVIER — JONCKHEERE, given by MR. OLIVIER (*A. J.* 714 and 733) definitely prove that my measures are 0″.31 too small. One might perhaps feel inclined to divide this difference between the two observers. Only three of the J stars measured by MR. OLIVIER had been previously measured in America, but these give the following comparison:

(893) J 7

	°	″		
1913.09	211.2	1.09	4*n*	Doo.
1917.85	209.1	1.78	2*n*	OLIV.

(1137) J 18

1913.16	190.0	0.74	3*n*	Doo.
1917.91	188.1	1.64	2*n*	OLIV.

(2095) J 82

1912.23	110.9	1.79	3*n*	Doo.
1917.12	111.0	2.05	3*n*	OLIV.

I think, personally, that this method of comparison is objectionable, and it is for this reason that I have not answered MR. OLIVIER's first paper, (*A. J.* 714).

All one should do, is to take the arithmetic mean of the observations as giving probably the best representation of the true position.

As I mentioned in the introduction to my catalogue, observers will find a very different order of accuracy to that of the usual double star measures when they start to re-observe these recently discovered stars. MR. OLIVIER mentions that these stars are very difficult objects even with a 26-inch refractor. I have found the same difficulty here with the 28-inch and I believe that for these faint stars, even measures in good agreement are often deceptive.

(4) J 865 9.3 — 10.0

	°	″
1916.890	75.2	1.09
17.925	71.6	1.21
18.887	76.6	1.29
1917.90	74.5	1.20

AC 9.4 — 9.4

1917.925	9.8	25.60
18.887	7.1	25.69
1918.41	8.5	25.65

J 1320 *B.D.* +19° 5207
0ʰ 2ᵐ 7ˢ +19° 36′
9.5 — 11.5

	°	″
1917.953	320.0	3.00
18.085	323.2	3.40
1918.02	321.6	3.20

(19) A 1801 9.0 — 9.0

1916.906	191.0	0.42
17.947	195.2	0.60
1917.43	193.1	0.51

(22) J 867 8.9 — 11.2

	°	″
1916.906	183.0	1.24
17.925	185.2	0.90
1917.42	184.1	1.07

(28) J 216 10.2 — 10.2

1916.890	164.6	2.91
16.906	169.0	3.26
1916.90	166.8	3.09

J 1321 *B.D.* +14° 21′
0ʰ 12ᵐ 6ˢ +15° 11′
9.6 — 14.2

	°	″
1916.800	101.0	2.57
18.085	105.0	2.26
1917.44	103.0	2.42

(39) J 869 9.5 — 9.5

1917.947	248.2	1.00
18.085	252.4	1.17
1918.02	250.3	1.09

(45) J 218 9.9 — 11.8

	°	″
1916.895	0.3	3.64
17.925	2.0	4.00
1917.41	1.2	3.82

(46) J 920 9.7 — 10.2

1916.895	197.2	2.07
18.079	212.6	2.17
1917.49	204.9	2.27

(60) J 631 9.6 — 9.7

1916.895	111.0	4.04
18.079	112.2	3.41
1917.49	111.6	3.73

(61) J 632 9.4 — 9.4

1916.895	84.2	1.65
18.079	83.8	2.09
1917.49	84.0	1.87

(68) J 871 9.7 — 9.7

1916.895	358.6	1.81
17.925	356.0	2.07
1917.41	357.3	1.94

(69) J 168 9.3 — 9.3

1916.895	173.2	1.21
17.925	169.8	0.96
1917.41	171.5	1.10

AC h 1976 9.3 — 11.8

1916.895	262.2	12.33
17.925	264.6	12.36
1917.41	263.4	12.35

(70) J 633 9.5 — 12.5

1916.895	308.0	1.80
18.082	305.2	1.85
18.085	302.8	2.01
1917.69	305.3	1.89

(72) J 584 8.9 — 11.9

1916.895	174.0	2.71
17.925	174.0	3.14
1917.41	174.0	2.93

(73) J 634 9.8 — 11.8

1916.895	276.0	2.05
17.925	275.0	2.32
1917.41	275.5	2.19

(77) J 921 9.2 — 9.2

	°	″
1916.890	234.0	3.13
16.895	234.6	2.87
1916.89	234.3	3.00

(85) J 923 9.4 — 9.4

1916.895	219.8	4.12
17.099	221.8	4.40
1917.00	220.8	4.26

(93) J 585 9.0 — 9.2

1916.895	213.2	1.44
18.082	216.0	1.21
1917.49	214.6	1.33

(107) J 636 9.3 — 10.1

1916.895	264.8	1.72
18.082	262.6	2.08
1917.49	263.7	1.90

(109) J 223 9.3 — 9.5

1916.895	99.6	1.18
18.082	99.0	1.00
1917.49	99.3	1.09

(110) J 924 9.3 — 9.5

1916.895	304.6	3.40
17.099	305.0	3.34
1917.00	304.8	3.37

(121) J 637 9.6 — 10.2

1916.895	173.8	2.80
18.123	171.6	2.39
18.126	174.8	2.35
1917.71	173.4	2.51

(127) J 638 9.7 — 9.7

1916.895	206.0	3.31
18.126	208.2	3.02
1917.51	207.1	3.17

(136) J 586 9.4 — 9.4

1916.895	224.2	1.12
18.085	222.0	1.18
1917.49	223.1	1.15

(149) J 873 9.8 — 12.0

1916.904	207.2	2.53
18.126	213.6	2.89
1917.52	210.4	2.71

(150) J 874 9.9 — 12.8

		″
1916.895	339.6	3.68
18.126	343.6	3.78
1917.51	341.6	3.73

(163) J 926 9.8 — 10.5

1916.904	131.2	2.53
18.126	118.6	1.93
1917.52	124.9	1.23

(170) J 515 9.1 — 9.1

1916.904	186.6	3.02
18.126	189.8	2.95
1917.52	188.2	2.99

(181) J 224 8.8 — 12.5

1916.904	267.0	4.22
18.126	256.6	4.58
1917.52	261.8	4.40

(190) J 225 9.9 — 10.3

1916.904	210.2	2.44
18.994	207.0	2.75
1917.95	208.6	2.60

AC 9.9 — 11.2

1916.904	201.8	25.89
18.994	203.0	26.48
1917.95	202.4	26.19

(191) J 226 9.3 — 9.8

1916.904	66.4	3.94
18.994	64.0	4.42
1917.95	65.2	4.18

(200) J 227 9.5 — 12.3

1916.904	180.8	2.93
18.994	176.0	3.13
1917.95	178.4	3.03

(201) J 639 9.9 — 9.9

1916.904	126.8	4.18
18.994	127.2	1.88
1917.95	127.0	1.53

(227) J 640 9.2 — 9.2

1916.904	38.8	1.06
18.994	39.4	1.05
1917.95	39.1	1.06

(236) J 228 8.8 — 10.3

	°	″
1916.904	102.2	3.10
18.994	102.8	3.62
1917.95	102.5	3.36

(407) A 2023 9.2 — 9.2

1916.906	229.6	0.57
17.121	226.4	0.64
1917.01	228.0	0.61

(516) A 2344 8.6 — 9.7

1917.121	184.6	1.11
17.153	184.4	1.21
1917.14	184.5	1.16

(545) A 2420 8.6 — 9.8

1917.121	271.2	1.91
17.123	269.2	2.33
1917.12	270.2	2.12

(595) J 306 9.2 — 9.7

1917.121	91.6	1.85
17.123	89.8	1.97
1917.12	90.7	1.91

(630) A 1298 8.6 — 10.5

1917.071	141.4	1.35
17.121	145.6	1.22
1917.10	143.5	1.29

(686) A 2036 9.3 — 10.8

1917.071	288.2	2.74
17.123	286.6	2.33
1917.10	287.4	2.54

(793) J 323 7.9 — 9.8

1917.121	165.4	2.95
18.134	166.0	3.56
1917.63	165.7	3.26

(909) J 246 9.2 — 9.2

1917.121	334.8	3.88
17.208	329.8	3.78
17.222	331.8	3.62
1917.18	332.1	3.76

J 1322 *B.D.* +11° 985
$5^h\ 54^m\ 47^s$ +11° 4′
9.3 — 9.4

	°	″
1917.107	217.4	2.05
18.085	218.2	1.89
1917.60	217.8	1.97

(1055) J 407 8.6 — 10.2

1917.121	194.2	2.05
17.318	199.0	2.51
18.134	195.4	2.09
1917.52	196.2	2.22

J 1323 *B.D.* +9° 1067
$5^h\ 58^m\ 34^s$ +9° 46′
9.8 — 9.9

1918.134	146.8	0.93
18.994	148.0	0.80
1918.56	147.4	0.87

(1114) J 255 9.4 — 9.5

1918.079	131.8	2.56
18.082	126.6	3.08
1918.08	129.2	2.82

(1195) J 718 8.9 — 12.3

1918.079	153.0	3.32
18.082	156.0	3.70
1918.08	154.5	3.51

(1197) J 974 9.8 — 10.0

1917.107	201.4	4.28
18.079	196.0	4.56
1917.59	198.7	4.42

(1200) J 346 9.8 — 10.0

1917.107	221.2	1.48
18.079	216.0	2.27
18.082	212.2	2.05
1917.76	216.5	1.93

J 1324 Anon.
$6^h\ 17^m\ 28^s$ +11° 5′
10.2 — 13.5

1918.079	67.0	3.35
18.082	71.4	2.81
1918.08	69.2	3.08

(1201) J 258 9.2 — 10.2

	°	″
1917.107	260.2	1.97
18.079	261.8	2.05
18.082	260.6	2.54
1917.76	260.9	2.19

(1202) J 410 9.5 — 9.7

1917.107	352.0	2.71
18.079	352.6	3.20
1917.59	352.3	2.96

(1203) J 347 7.8 — 10.8

1918.079	162.6	1.97
18.082	163.8	2.33
1918.08	163.2	2.15

(1211) J 53 6.9 — 10.5

1917.107	127.6	1.57
18.082	127.6	2.02
1917.59	127.6	1.80

AC 6.9 — 9.8

1917.107	103.4	33.65
18.082	103.5	33.95
1917.59	103.5	33.80

(1215) J 688 9.4 — 10.1

1917.107	111.4	1.29
17.329	114.5	1.27
18.082	109.0	1.87
1917.47	111.6	1.48

(1216) J 259 8.5 — 10.4

1918.082	319.6	5.39
18.162	320.6	5.25
1918.12	320.1	5.32

(1245) J 660 9.1 — 9.1

1917.107	99.0	2.16
17.307	99.2	2.75
1917.21	99.1	2.46

(1270) J 982 9.1 — 9.6

1917.107	223.0	2.71
17.307	226.0	3.20
1917.21	224.5	2.96

(1334) J 989 9.0 — 9.7

	°	″
1917.208	98.4	1.18
17.307	91.4	1.51
1917.26	94.9	1.35

(1340) J 412 9.2 — 9.6

1917.208	23.2	3.95
17.307	24.6	4.43
1917.26	23.9	4.19

(1341) A 2823 8.7 — 9.4

1917.208	296.8	4.22
17.307	298.4	4.26
1917.26	297.6	4.24

(1351) J 667 9.2 — 9.8

1917.208	72.2	3.59
17.307	75.2	3.90
1917.26	73.7	3.75

(1356) J 1106 9.4 — 9.7

1917.208	258.4	1.36
17.307	263.0	1.93
1917.26	260.7	1.65

(1357) J 267 9.3 — 9.3

1917.123	83.2	1.76
17.181	89.3	1.42
17.208	87.7	1.72
17.212	87.2	1.95
18.079	86.6	2.07
1917.36	86.8	1.78

(1361) J 724 9.6 — 9.8

1917.208	172.8	2.85
17.307	166.6	2.32
1917.26	169.7	2.59

(1366) J 268 10.2 — 11.1

1917.123	353.4	4.44
17.307	346.6	3.97
1917.22	350.0	4.21

(1424) J 273 9.0 — 9.0

1917.123	336.4	4.29
18.079	340.2	4.28
1917.60	338.3	4.29

AC 9.0 — 12.9

	°	″
1917.123	219.0	10.74
18.079	214.6	11.22
1917.60	216.8	10.98

(1426) J 600 9.3 — 9.7

1917.123	64.2	3.45
17.307	68.8	4.26
18.134	60.0	3.77
1917.52	64.3	3.83

J 1325 *B.D.* +5° 1475
$6^h\ 51^m\ 32^s$ +5° 0′
9.4 — 11.0

1918.134	153.2	2.92
18.894	151.4	2.48
1918.51	152.3	2.70

(1435) J 276 9.8 — 10.7

1917.123	14.0	1.20
18.079	23.4	1.66
1917.60	18.7	1.43

(1481) J 728 8.6 — 9.3

1917.123	68.0	2.57
17.307	72.8	2.80
1917.22	70.4	2.69

(1642) J 45 9.4 — 10.2

1917.123	188.8	2.47
18.134	180.2	2.53
1917.63	184.5	2.50

(1688) J 46 9.3 — 11.9

1917.123	277.0	1.29
17.222	281.0	2.05
1917.17	279.0	1.67

(1693) J 69 9.2 — 11.2

1917.123	256.8	1.50
17.222	260.0	2.27
1917.17	258.4	1.89

(1826) J 735 8.9 — 8.9

1917.222	158.0	2.67
17.298	155.6	2.39
17.348	150.4	2.35
1917.29	154.7	2.47

(1839) Van 3 9.0 — 9.2

	°	″
1917.123	91.6	1.93
17.222	92.6	2.33
17.298	93.8	1.97
17.348	92.2	1.91
18.222	92.0	2.41
1917.44	92.4	2.11

(1865) J 744 9.4 — 11.6

1917.123	256.6	1.56
17.222	264.2	2.19
17.298	264.6	1.67
1917.21	261.8	1.81

(1872) J 77 8.9 — 9.3

1917.211	140.6	1.48
17.298	143.4	0.88
17.348	134.4	0.90
18.257	148.8	0.94
1917.53	141.8	1.05

(1895) J 804 9.5 — 10.8

1917.211	277.0	3.22
17.222	276.2	3.26
17.298	275.2	2.89
1917.24	276.1	3.12

(1898) A 2556 9.0 — 9.7

1917.222	319.4	1.03
17.312	307.0	0.93
1917.27	313.2	0.98

(1923) J 387 10.5 — 11.1

1917.211	359.8	4.62
17.222	359.0	4.38
1917.22	359.4	4.50

(1911) J 78 9.3 — 10.0

1917.211	210.2	3.92
17.307	207.8	3.53
1917.26	209.0	3.73

(1951) A 2761 8.8 — 9.0

1917.222	239.0	0.55
17.312	238.0	0.60
1917.27	238.5	0.58

(1960) A 2560 8.7 — 9.3

1917.222	12.4	0.86
17.312	4.4	0.94
1917.27	8.4	0.90

(1986) A 2564 9.1 — 9.1

	°	″
1917.222	271.0	0.63
17.312	270.8	0.58
1917.27	270.9	0.61

(1996) A 2764 9.0 — 11.0

1917.222	3.4	1.47
17.312	0.8	1.03
1917.27	2.1	1.25

(1997) A 2566 9.0 — 10.0

1917.222	84.0	1.32
17.312	81.4	1.06
1917.27	82.7	1.19

(2003) J 1126 9.2 — 9.6

1917.211	307.8	2.26
17.311	301.6	2.05
17.348	304.0	2.05
1917.29	304.5	2.12

(2092) J 81 9.1 — 9.4

1918.216	140.0	1.77
18.337	141.1	1.62
1918.28	140.6	1.70

(2097) J 1011 9.1 — 9.3

1918.216	70.0	2.95
18.337	69.6	2.35
1918.28	69.8	2.65

(2133) J 87 8.5 — 11.5

1917.211	136.4	1.74
17.222	135.8	1.61
17.312	130.6	1.29
17.449	138.2	1.15
1917.30	135.3	1.44

(2211) J 432 8.4 — 9.1

1917.307	264.6	0.98
17.312	270.6	0.63
17.468	260.8	0.70
1917.36	265.3	0.77

(2225) A 1785 9.0 — 10.2

1917.307	124.6	2.05
17.312	122.4	1.45
17.468	132.2	1.83
1917.36	126.4	1.78

(2230) A 1786 9.3 — 10.2

	°	″
1917.307	93.0	4.82
17.312	93.0	5.04
17.468	95.2	5.28
1917.36	93.7	5.05

(2245) A 2585 8.8 — 9.0

1917.307	230.6	0.81
17.312	230.8	0.66
1917.31	230.7	0.74

(2295) A 2065 8.7 — 10.0

1917.307	339.4	1.93
17.312	341.2	1.86
17.460	336.4	1.61
17.468	337.4	1.89
1917.39	338.6	1.82

(2307) J 1121 9.3 — 10.5

1917.307	159.6	3.50
17.312	159.8	3.23
17.468	154.2	3.68
1917.36	157.9	3.47

(2315) J 439 9.4 — 11.2

1917.307	239.4	3.35
17.312	241.2	3.52
17.468	235.0	3.35
1917.36	238.5	3.41

(2317) A 2069 8.8 — 8.8

1915.320	216.8	0.24
17.518	213.6	0.28
1916.42	215.2	0.26

(2324) J 1122 9.2 — 9.9

1917.307	275.4	1.29
17.312	274.2	1.00
17.468	275.2	1.27
1917.36	274.9	1.19

(2332) A 2071 8.5 — 9.0

1916.380	260.6	0.64
17.509	260.0	0.90
18.405	264.3	0.84
1917.43	261.6	0.79

(2335) J 440 9.3 — 9.3

	°	″
1917.307	41.2	2.98
17.312	44.0	2.56
17.460	39.4	2.65
17.468	43.0	2.33
1917.39	41.9	2.63

(2357) J 1030 9.9 — 10.6

1917.307	62.6	3.58
17.312	61.2	3.41
17.468	60.4	4.22
1917.36	61.4	3.74

(2370) J 442 9.5 — 11.5

1917.307	88.2	4.24
17.312	89.4	3.41
17.468	91.2	3.92
18.405	89.2	4.18
1917.62	89.5	3.94

(2376) J 443 9.0 — 12.0

1917.307	239.4	4.34
17.312	239.6	3.84
17.468	233.8	3.86
18.405	234.6	4.04
1917.62	236.9	4.02

(2380) A 2075 8.9 — 10.8

1917.482	128.6	0.45
17.518	135.6	0.65
1917.50	132.1	0.55

(2395) A 2078 8.3 — 9.0

1917.482	156.2	0.87
17.509	155.2	1.00
1917.50	155.7	0.94

(2405) J 416 9.7 — 9.7

1917.307	182.6	3.80
17.468	186.4	3.75
1917.39	184.5	3.78

(2408) A 2178 8.9 — 10.7

1917.482	321.6	0.81
17.518	330.0	1.10
1917.50	325.8	0.96

(**2415**) A 2083 9.2 — 9.2

	°	″
1917.482	149.2	0.96
17.509	145.2	0.60
1917.50	147.2	0.78

(**2421**) J 399 9.1 — 11.8

1917.307	51.2	4.56
17.452	49.4	4.05
17.468	51.2	4.61
1917.41	50.6	4.41

(**2427**) A 2233 9.0 — 9.6

1917.509	26.6	2.39
18.433	25.8	2.92
1917.97	26.2	2.66

(**2429**) A 2084 9.1 — 9.2

1917.482	177.0	0.35
18.518	173.6	0.45
1917.50	175.3	0.40

(**2430**) A 1860 8.9 — 10.9

1917.482	83.0	3.40
17.509	82.2	3.05
1917.50	82.6	3.23

(**2437**) J 447 8.9 — 10.5

1917.452	237.8	5.31
17.561	238.6	4.48
1917.51	238.2	4.90

(**2438**) J 738 9.9 — 9.9

1917.307	247.2	1.72
17.545	246.6	1.69
17.561	247.8	1.81
18.433	250.0	1.81
18.753	248.5	1.38
1917.92	248.0	1.68

In the Catalogue, for 22° 4′, read 21° 55′, the first value was for 1855.

J 1326 Anon.
$16^h\ 40^m\ 45^s$ +22° 9′
11.8 — 12.0

1917.449	237.2	1.83
17.468	229.4	1.69
17.561	231.0	1.47
1917.49	232.5	1.66

AC 11.8 — 1.35

	°	″
1917.449	55.0	5.55
17.468	58.2	5.31
17.561	57.4	5.43
1917.49	56.9	5.43

(**2482**) A 2086 9.2 — 10.3

1917.482	205.4	3.04
17.509	205.0	2.93
1917.50	205.2	2.99

(**2496**) J 452 9.2 — 10.7

1917.307	301.4	2.44
17.449	301.4	2.63
17.468	296.8	2.29
1917.41	299.7	2.45

(**2507**) A 2245 8.6 — 9.5

1917.490	348.6	1.98
17.509	348.6	2.33
1917.50	348.6	2.16

(**2911**) A 1652 8.8 — 11.7

1912.400	131.6	1.77
17.523	130.4	1.57
1914.96	131.0	1.67

(**2983**) A 2788 9.0 — 10.0

1915.830	311.3	0.80
17.523	325.6	1.23
1916.68	318.5	1.02

(**3068**) J 25 9.4 — 9.4

1917.449	1.4	1.59
17.769	4.4	1.57
1917.61	2.9	1.58

(**3099**) A 1663 8.6 — 8.9

1915.690	227.3	1.21
17.523	229.0	1.27
1916.61	228.2	1.24

(**3152**) A 1413 9.2 — 10.2

1910.470	140.0	2.25
17.523	141.8	2.11
1914.00	140.9	2.18

(**3188**) J 549 9.3 — 12.4

	°	″
1916.835	295.0	4.10
17.769	295.0	4.98
1917.30	295.0	4.54

(**3217**) J 508 9.7 — 10.9

1917.769	146.4	2.41
18.726	144.9	2.83
1918.25	145.7	2.62

(**3312**) A 1680 8.5 — 10.4

1911.640	293.2	3.81
17.523	297.0	3.20
1914.58	295.1	3.51

(**3357**) J 156 9.3 — 9.4

1917.769	20.4	1.95
18.726	23.1	2.39
1918.25	21.8	2.17

(**3361**) A 2795 7.5 — 7.5

1915.650	212.0	0.15
17.523	208.0	0.30
1916.59	210.0	0.23

(**3372**) J 193 8.6 — 11.0

1917.849	86.4	5.34
18.726	86.1	5.43
1918.29	86.3	5.39

(**3376**) J 513 9.0 — 12.2

1917.849	162.0	3.94
18.890	167.0	4.28
1918.37	164.5	4.11

(**3387**) J 1074 10.6 — 10.7

1917.849	292.2	1.95
18.890	297.6	1.54
1918.37	294.9	1.75

In the catalogue, for: 25° 33′, read 25° 38′.

(**3388**) J 514 10.0 — 10.2

1917.849	142.2	2.53
18.890	150.0	2.41
1918.37	146.1	2.47

(**3396**) J 194 8.8 — 8.8

	°	″
1917.849	36.0	0.84
18.890	33.4	0.90
1918.37	34.7	0.87

AB — C 8.4 12.0

1917.849	91.0	23.66
18.890	89.8	23.94
1918.37	90.4	23.80

J 1327 Anon.
$20^h\ 48^m\ 33^s$ +22° 0′
9.8 — 9.8

1916.670	63.9	3.28
18.753	58.3	2.79
1917.71	61.1	3.04

J 1328 *B.D.* +25° 4469
$21^h\ 4^m\ 34^s$ +25° 54′
9.2 — 9.4

1917.800	130.0	0.48
17.925	124.2	0.56
18.887	127.8	0.66
1918.20	127.3	0.57

(**3446**) A 1689 9.0 — 9.0

1912.830	342.6	2.15
17.523	340.2	2.20
1915.18	341.4	2.18

(**3484**) J 577 9.3 — 10.4

1917.800	23.4	2.41
18.890	22.2	2.32
1918.35	22.8	2.37

J 1329 Anon.
$21^h\ 10^m\ 31^s$ +35° 42′
10.0 — 12.0

1916.610	156.1	2.75
18.890	163.8	2.53
1917.75	160.0	2.64

(**3517**) J 1244 8.5 — 8.8

1917.849	103.6	2.89
18.726	102.7	2.93
18.928	104.2	3.01
1918.50	103.5	2.94

(3635) J 289 9.9 — 10.8

	°	″
1917.449	139.6	1.97
17.769	137.4	1.57
18.928	136.8	1.20
1918.05	137.9	1.58

(3637) J 1246 9.9 — 10.0

1917.769	356.4	2.77
18.890	354.4	2.30
18.928	354.0	3.01
1918.53	354.9	2.69

J 1330 Anon.
$22^h\,12^m\,34^s$ $+34°\,23'$
10.0 — 10.5

	°	″
1916.840	313.8	2.91
18.890	301.4	2.20
1917.87	307.6	2.56

(3911) E 268 9.1 — 10.3

1917.813	277.7	0.96
17.849	281.6	1.15
17.925	272.8	0.97
1917.86	277.4	1.03

AC 9.1 — 11.2

	°	″
1917.813	270.0	4.10
17.849	267.0	4.26
17.925	266.4	4.64
1917.86	267.8	4.33

(3912) J 300 9.1 — 9.7

1917.849	6.2	3.29
18.890	10.4	3.86
18.928	7.4	3.26
1918.56	8.0	3.47

Royal Observatory, Greenwich, 1919, January 10.

OBSERVATIONS OF MINOR PLANETS.

MADE WITH THE 12-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By WM. A. CONRAD.

[Communicated by Rear-Admiral J. A. HOOGEWERFF, U. S. N. Superintendent.]

Date	Wash. M.T.	✻	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log $p\Delta$ α	Log $p\Delta$ δ	Red. to App. Pl. α	Red. to App. Pl. δ
					(15) *Eunomia*						
1918	h m s			m s	′ ″	h m s	° ′ ″			s	″
Feb. 28	11 40 34	1	25, 5	−4 19.81	+ 1 38.4	8 58 58.26	+ 7 50 24.5	9.168	0.659	+2.84	−13.9
					(78) *Diana*						
Mar. 2	11 0 50	2	25, 5	−2 56.99	− 1 2.6	10 6 34.58	+11 13 35.4	8.709*n*	0.609	+2.95	−16.2
					(385) *Ilmatar*						
Mar. 17	11 4 39	3	28, 6	−0 50.96	− 5 42.7	10 56 39.60	+ 5 26 33.4	8.393*n*	0.683	+2.96	−18.4*
19	12 34 42	4	25, 5	+1 33.11	− 8 29.0	10 54 42.69	+ 5 25 1.4	9.234	0.688	+2.97	−18.5
					(64) *Angelina*						
Mar. 17	11 49 2	5	25, 5	−0 53.54	+ 7 18.5	10 51 25.63	+ 5 49 44.9	8.873	0.681	+2.95	−18.3*
19	12 6 5	6	30, 6	+0 12.92	+ 2 38.9	10 49 53.87	+ 5 58 24.6	9.102	0.680	+2.96	−18.3
					(192) *Nausikaa*						
Sept. 9	16 20 15	7	40, 8	+3 9.72	− 4 3.4	1 8 6.17	+12 11 39.5	9.446	0.625	+4.39	+25.0
14	13 13 4	8	25, 5	−2 24.35	+ 2 3.9	1 5 47.74	+12 38 41.7	8.591*n*	0.588	+4.48	+25.8
15	11 6 43	9	25, 5	+3 19.25	− 6 1.4	1 5 15.95	+12 43 15.4	9.433*n*	0.616	+4.50	+25.9
23	15 11 29	10	24, 5	−2 51.77	−10 46.4	0 59 29.53	+13 16 30.2	9.434	0.609	+4.61	+27.0
27	14 21 2	11	25, 5	−3 30.51	− 2 41.4	0 56 6.23	+13 27 34.7	9.336	0.595	+4.68	+27.7
Oct. 8	9 3 29	12	24, 5	+3 27.35	+ 8 13.4	0 45 53.23	+13 42 2.9	9.469*n*	0.610	+4.72	+29.2
8	9 3 29	13	24, 4	+0 41.85	+ 8 26.0	0 45 52.83	+13 42 1.4	9.469*n*	0.610	+4.72	+29.2
8	9 3 29	14	23, 5	−1 7.02	+ 3 10.8	0 45 53.06	+13 42 1.3	9.469*n*	0.610	+4.72	+29.2
8	9 3 29	15	24, 5	−2 45.57	− 0 46.3	0 45 53.26	+13 42 1.1	9.469*n*	0.610	+4.72	+29.2
22	8 2 6	16	25, 5	+1 24.84	+ 7 46.3	0 33 39.29	+13 36 11.8	9.454*n*	0.608	+4.73	+30.5
22	8 2 6	17	25, 5	−1 43.09	+ 4 11.5	0 33 39.38	+13 36 12.2	9.454*n*	0.608	+4.73	+30.5
22	8 2 6	18	25, 5	−1 58.48	+ 2 16.7	0 33 39.14	+13 36 10.5	9.454*n*	0.608	+4.73	+30.5

Date	Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	Log pΔ α	Log pΔ δ	Red. to App. Pl. α	Red. to App. Pl. δ
				(198) *Ampella*							
1918	h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 13	8 16 13	19	25 , 5	−1 42.86	+ 5 1.9	22 6 30.03	+ 8 8 46.3	9.427*n*	0.668	+4.32	+27.8*
14	10 44 25	20	25 , 5	+1 46.67	+ 2 30.0	22 5 46.47	+ 8 3 35.2	8.378	0.652	+4.33	+28.0
15	8 54 6	21	25 , 5	+3 11.45	+ 2 23.9	22 5 12.01	+ 7 59 3.2	9.266*n*	0.660	+4.32	+27.9
23	8 12 27	22	25 , 5	+2 9.30	+ 1 9.3	22 1 12.95	+ 7 16 8.5	9.292*n*	0.669	+4.27	+28.4
27	12 51 6	23	29 , 6	+0 8.08	+ 3 31.3	21 59 54.86	+ 6 50 21.0	9.541	0.692	+4.26	+28.7
Oct. 3	10 29 30	24	25 , 5	+3 2.13	− 2 24.0	21 59 8.46	+ 6 17 30.5	9.188	0.677	+4.20	+28.8
3	10 29 30	25	25 , 5	−2 6.74	+ 0 40.7	21 59 8.46	+ 6 17 30.1	9.188	0.677	+4.20	+28.8
				(554) *Peraga*							
Sept. 14	12 22 5	26	25 , 5	−3 10.36	+ 0 13.2	23 41 55.26	+ 3 5 8.0	8.435	0.710	+4.46	+29.0
15	10 16 47	27	30 , 6	−1 12.06	− 0 32.1	23 41 4.23	+ 3 0 51.8	9.315*n*	0.713	+4.48	+29.1
23	14 20 37	28	25 , 5	+1 34.87	+ 5 32.0	23 33 25.58	+ 2 19 52.8	9.503	0.725	+4.50	+29.5
27	13 31 5	29	24 , 5	−1 58.85	− 1 7.1	23 29 49.00	+ 1 58 53.8	9.435	0.724	+4.52	+29.8
Oct. 3	11 15 48	30	25 , 5	+1 12.19	+ 1 14.6	23 24 48.09	+ 1 27 51.0	8.891	0.726	+4.50	+29.8
3	11 15 48	31	25 , 5	−1 24.99	− 5 9.9	23 24 48.41	+ 1 27 53.5	8.891	0.726	+4.50	+29.8
7	8 30 58	32	25 , 5	−0 50.27	− 9 4.3	23 21 51.01	+ 1 6 17.7	9.315*n*	0.731	+4.47	+29.7
				(712) *Boliviana*							
Sept. 27	11 53 20	33	24 , 5	+2 39.95	− 4 20.4	1 38 12.95	+23 15 48.8	9.232*n*	0.399	+4.88	+23.8
				(39) *Lætitia*							
Oct. 3	12 6 15	34	25 , 5	+3 9.69	− 8 45.6	1 0 47.22	− 4 10 49.0	8.093*n*	0.777	+4.54	+28.6
3	12 6 15	35	25 , 5	+1 32.97	+ 3 52.3	....	....	8.093*n*	0.777	+4.54	+28.6†
7	16 7 16	36	23 , 5	+2 6.87	− 1 58.9	0 57 43.71	− 4 47 19.5	9.614	0.758	+4.55	+28.4
7	16 7 16	37	25 , 5	−4 11.46	− 3 7.3	0 57 43.58	− 4 47 19.0	9.614	0.758	+4.55	+28.4
8	10 43 52	38	30 , 6	+1 34.03	− 0 20.1	0 57 9.80	− 4 53 50.3	9.111*n*	0.781	+4.56	+28.4
8	10 43 52	39	30 , 6	−0 2.54	− 3 2.5	0 57 9.73	− 4 53 51.8	9.111*n*	0.781	+4.56	+28.4
8	10 43 52	40	30 , 6	−0 13.88	− 1 48.8	0 57 9.92	− 4 53 52.8	9.111*n*	0.781	+4.56	+28.4
22	9 12 17	41	20 , 5	+3 41.99	− 8 0.2	0 47 29.41	− 6 33 54.2	9.257*n*	0.791	+4.60	+27.8
22	9 12 17	42	20 , 5	+2 19.43	+ 2 38.6	0 47 29.23	− 6 33 54.2	9.257*n*	0.791	+4.60	+27.8
22	9 12 17	43	19 , 5	+1 20.05	+ 4 3.3	0 47 28.91	− 6 33 52.6	9.257*n*	0.791	+4.60	+27.8
22	9 12 17	44	25 , 5	−0 10.15	− 1 36.0	0 47 29.22	− 6 33 54.9	9.257*n*	0.791	+4.60	+27.8
				(101) *Helena*							
Nov. 3	12 51 6	45	36 , 8	+2 5.84	+ 9 45.0	0 39 14.83	+16 41 19.3	9.547	0.595	+4.76	+31.2
3	12 53 15	46	29 , 7	+1 42.63	+10 50.0	0 39 14.81	+16 41 20.4	9.551	0.597	+4.76	+31.2
3	12 51 6	47	36 , 8	−2 10.98	+ 4 28.9	0 39 14.85	+16 41 17.0	9.547	0.595	+4.76	+31.2
3	12 51 6	48	36 , 8	−4 23.80	+10 3.0	0 39 15.01	+16 41 19.9	9.547	0.595	+4.76	+31.2
3	12 51 6	49	35 , 8	−5 29.92	+10 53.9	0 39 14.79	+16 41 17.9	9.547	0.595	+4.76	+31.2
7	8 42 29	45	46 , 10	−0 7.73	− 2 16.7	0 37 1.26	+16 29 18.5	9.003*n*	0.528	+4.75	+31.4
7	8 42 29	46	46 , 10	−0 30.92	− 1 10.9	0 37 1.26	+16 29 20.3	9.003*n*	0.528	+4.75	+31.4
14	11 44 6	50	25 , 0	+3 5.02	....	0 34 2.09	....	9.494	..	+4.68	....**
14	11 44 6	51	25 , 0	+2 23.75	....	0 34 2.19	....	9.494	..	+4.68	....**
14	11 44 6	52	25 , 0	+0 55.73	....	0 34 1.92	....	9.494	..	+4.68	....**
14	11 44 6	53	25 , 0	−2 12.46	....	0 34 1.87	....	9.494	..	+4.68	....**
14	11 44 6	54	25 , 0	−3 56.70	....	0 34 2.17	....	9.494	..	+4.68	....**
14	11 44 6	55	25 , 0	−4 37.86	....	0 34 2.25	....	9.494	..	+4.68	....**

Date	Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log. $p\Delta$ α	Log. $p\Delta$ δ	Red. to App. Pl. α	Red. to App. Pl. δ
				(68) *Leto*							
1918	h m s			m s	″	h m s	° ′ ″			s	″
Nov. 6	11 51 20	56	30 , 6	+5 44.64	− 6 4.5	1 18 18.85	+ 4 31 47.3	9.268	0.698	+4.76	+27.5
6	11 51 20	57	30 , 6	+3 25.20	− 4 56.3	1 18 19.05	+ 4 31 43.1	9.268	0.698	+4.76	+27.5
6	11 51 20	58	30 , 6	+1 37.22	− 3 58.6	1 18 18.50	+ 4 31 45.4	9.268	0.698	+4.76	+27.5

* These asteroids were picked up for me by Mr. Geo. H. Peters with the 10-inch photographic equatorial.

† No good place for this comparison star is available.

** Bright moonlight. Too faint to observe in declination successfully.

Mean Places of Comparison Stars for the Beginning of the Year—1918.0.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	9 3 15.22	+ 7 49 0.0	*A.G. Leipzig II* 4965	30	23 23 31.38	+ 1 26 6.6	*A.G. Albany* 8081
2	10 9 28.62	+11 14 54.3	*A.G. Leipzig I* 3969	31	23 26 8.90	+ 1 32 33.6	*A.G. Albany* 8086
3	10 57 27.60	+ 5 32 34.5	*A.G. Leipzig II* 5662	32	23 22 36.81	+ 1 14 52.3	*A.G. Albany* 8077
4	10 53 6.61	+ 5 33 48.8	*A.G. Leipzig II* 5639	33	1 35 28.12	+23 19 45.2	*A.G. Berlin B* 505
5	10 52 16.21	+ 5 42 44.7	*A.G. Leipzig II* 5634	34	0 57 32.99	− 4 2 32.1	*A.G. Straszburg* 228
6	10 49 37.99	+ 5 56 4.0	*A.G. Leipzig II* 5625	35	. . . . . .	. . . . . .	*B.D.* −4° 133
7	1 4 52.07	+12 15 17.7	*A.G. Leipzig I* 311	36	0 55 32.29	− 4 45 49.1	*A.G. Straszburg* 216
8	1 8 7.61	+12 36 12.1	*A.G. Leipzig I* 332	37	1 1 50.49	− 4 44 40.0	*A.G. Straszburg* 242
9	1 1 52.19	+12 48 50.7	*A.G. Leipzig I* 292	38	0 55 31.21	− 4 53 58.7	*A.G. Straszburg* 215
10	1 2 16.69	+13 26 49.8	*A.G. Leipzig I* 294	39	0 57 7.71	− 4 51 17.7	*A.G. Straszburg* 225
11	0 59 32.06	+13 29 48.6	*A.G. Leipzig I* 277	40	0 57 19.24	− 4 52 32.4	*A.G. Straszburg* 227
12	0 42 21.16	+13 33 20.4	*A.G. Leipzig I* 206	41	0 43 42.83	− 6 26 22.0	*A.G. Wien-Ottak.* 157
13	0 45 6.26	+13 33 6.4	*A.G. Leipzig I* 219	42	0 45 5.21	− 6 37 0.7	*A.G. Wien-Ottak.* 159
14	0 46 55.36	+13 38 21.6	*A.G. Leipzig I* 227	43	0 46 4.26	− 6 38 23.8	*A.G. Wien-Ottak.* 162
15	0 48 34.10	+13 42 18.5	*A.G. Leipzig I* 236	44	0 47 34.77	− 6 32 46.7	*A.G. Wien-Ottak.* 169
16	0 32 9.73	+13 27 54.9	Bonn 236	45	0 37 4.24	+16 31 3.1	*A.G. Berlin A* 185
17	0 35 17.73	+13 31 30.3	*A.G. Leipzig I* 159	46	0 37 27.43	+16 29 59.2	*A.G. Berlin A* 188
18	0 35 32.88	+13 33 23.4	*A.G. Leipzig I* 162	47	0 41 21.06	+16 36 17.1	Bonn 296
19	22 8 8.56	+ 8 3 16.5	*A.G. Leipzig II* 11155	48	0 43 34.03	+16 30 46.0	*A.G. Berlin A* 214
20	22 3 55.46	+ 8 0 37.3	*A.G. Leipzig II* 11116	49	0 44 39.92	+16 29 53.1	Boss 174
21	22 1 56.24	+ 7 56 11.4	Bonn 9791	50	0 30 52.41	. . . . . .	*A.G. Berlin A* 164
22	21 58 59.39	+ 7 14 30.9	*A.G. Leipzig II* 11085	51	0 31 33.78	. . . . . .	*A.G. Berlin A* 168
23	21 59 42.52	+ 6 46 20.9	*A.G. Leipzig II* 11093	52	0 33 1.52	. . . . . .	*A.G. Berlin A* 171
24	21 56 2.15	+ 6 19 25.8	*A.G. Leipzig II* 11054	53	0 36 9.64	. . . . . .	*A.G. Berlin A* 181
25	22 1 11.00	+ 6 16 20.6	*A.G. Leipzig II* 11102	54	0 37 54.17	. . . . . .	*A.G. Berlin A* 192
26	23 45 1.16	+ 3 4 25.8	*A.G. Albany* 8165	55	0 38 35.40	. . . . . .	*A.G. Berlin A* 195
27	23 42 11.82	+ 3 1 54.9	*A.G. Albany* 8154	56	1 12 29.46	+ 4 37 24.0	*A.G. Albany* 347
28	23 31 46.22	+ 2 13 51.3	*A.G. Albany* 8119	57	1 14 49.10	+ 4 36 11.8	*A.G. Albany* 361
29	23 31 43.33	+ 1 59 31.1	*A.G. Albany* 8118	58	1 16 36.52	+ 4 35 16.4	*A.G. Albany* 367

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OBSERVATIONS OF VARIABLE STARS,

By WILLIAM DOBERCK.

(Continued from A. J. 748.)

RR Herculis: The Harvard comparison stars were used, but they are at some distance from the variable, which lowers the accuracy of the observations. The value of the step is 0.071. The maximum (8.10) occurred about 2421508, but the star did not change its magnitude for a month before and after the maximum. The minimum (8.80) occurred about 2421388. The period is 238.8 days. The formula, where x is counted from the minimum is: Mag. $= 8.34 + 0.34 \sin(x + 83°) + 0.10 \sin(2x + 79°)$.

0352	v = c	8.21	0774	a 2 v 1 b	8.04	1133	c 3 v 3 e	8.59	1457	b 1 v 2 c	8.12
0370	c 3 v 3 d	.40	0791	a 1 v 2 b	.00	1134	c 3 v 3 c	.59	1459	c 1 v	8.28
0374	d 2 v 3 e	.74	0801	a 2 v	.11	1152	c 4 v 1 d	.51	1473	v 1½ d	7.86
0381	c 5 v 4 d	.42	0931	v 3 c	.76	1158	d 2 v 2½ e	.76	1474	v = d	7.97
0391	c 2 v 2 d	.40	0952	v = b	.07	1168	d 1 v	.66	1484	c 5 v 5 d	8.40
0401	d 2 v 2 e	.78	0965	v = b	.07	1170	c 3 v 2 c	.67	1486	b 1 v 2 c	.12
0438	c 2 v 3 d	.36	0969	c 3 v 3 d	.40	1184	d 1 v 2 e	.72	1488	c 3 v 5 d	.35
0453	v 3 e	.76	0977	c 2 v 3 d	.36	1190	d 1 v 3 e	.68	1492	b 2 v 2 c	8.14
0467	v 3 d	.38	0984	v = b	.07	1207	a 3 v 1 b	.05	1493	v 1 a	7.90
0596	v 1 b	.00	0992	c 2 v 1 d	.46	1311	a 2 v 2 b	8.02	1503	a 1 v 2 b	8.00
0618	c 3 v 3 d	.40	1000	b 3 v 1 c	.18	1317	v 2½ a	7.79	1504	b 1 v 3 c	.11
0627	b 4 v 4 d	.33	1012	b 2 v 1 c	.16	1328	a 1 v	8.04	1507	c 1 v	.28
0640	d 2 v 2 e	.78	1036	v = b	.07	1339	v = a	7.97	1508	c 1 v 5 d	.27
0646	d 3 v 4 e	.75	1053	b 2 v 5 d	.22	1350	b 2½ v 2 c	8.17	1517	c 2 v 5 d	.32
0684	c 5 v 3 e	.68	1067	a 3 v 1 b	.05	1363	b 4½ v 1 c	.18	1522	c 2 v 4 d	.34
0708	b 6 v 3 e	.67	1075	b 3 v 3 c	.14	1375	d 2 v 2 e	.78	1537	v 1 c	.14
0716	c 3 v 4 d	.38	1077	c 3 v 3 d	.40	1388	d 3 v 1½ e	.84	1539	c 1½ v 4½ d	.30
0723	b 3½ v 3 d	.35	1080	c 4 v 3 d	.43	1391	c 4 v 2 d	.46	1549	v 1½ c	.10
0735	c 1 v 3 d	.30	1096	b 2 v 5 e	.33	1392	d 2 v 1½ l	.81	1565	c 3 v 3 d	.40
0746	b 1 v 1 c	.19	1113	v 3 d	.38	1429	c 2 v 3½ d	.35	1576	v 1 c	.14
0760	c 1 v 5 d	.27	1125	c 3 v 3 d	.40	1450	v = b	.07			

W Coronæ Borealis: The approximate magnitudes of the comparison stars have been determined in steps and converted into magnitudes by aid of GRAFF's values: *a* 7.40, *b* 8.21, *u* 8.86, *d* 8.93, *t* 9.11, *c* 9.13, *f* 9.21, *e* 9.38, *g* 9.57, *k* 10.09, *h* 10.54, *l* 10.60, *m* 10.67, *n* 10.69, *s* 10.94, and *r* 11.03. The maximum (7.90) occurred at 2421084. The value of the period is 239 days. The value of the step is 0.09 mag.

0331	d 2½ v 1 e	9.25	0342	v 5 d	8.48	0370	a 5 v 4 b	7.85	0391	b 4 v 5 d	8.53
0338	v 4 d	8.57	0352	v 1 b	8.12	0381	v 3 b	7.94	0396	b 5 v 4 d	8.61

0399	*b* 5 *v* 4 *d*	8.61	1080	*v* 2 *b*	8.03	1384	*g* 1 *v*	9.66	1758	*v* = *g*	9.57
0618	*b* 1 *v*	8.30	1084	*v* 3 *b*	7.94	1388	*g* 2 *v* 3 *k*	9.78	1760	*f* 2 *v* 3 *g*	9.36
0627	*b* 3 *v*	8.48	1096	*v* 3 *b*	7.94	1391	*g* 3 *v*	9.84	1761	*f* 1 *v* 3 *g*	9.30
0640	*v* 3 *d*	8.66	1113	*b* 5 *v* 3 *d*	8.66	1394	*g* 3 *v* 2 *k*	9.88	1767	*v* 1½ *d*	8.80
0646	*v* 3 *d*	8.66	1120	*d* 1 *v* 2 *c*	9.00	1501	*k* = *v*	10.09	1770	*b* 5 *v* 2 *d*	8.79
0653	*d* 3 *v* = *c*	9.16	1125	*d* 2 *v* 2 *c*	9.15	1503	*g* 3 *v* 3 *k*	9.83	1777	*b* 3 *v* 5 *d*	8.48
0664	*f* 1 *v*	9.30	1132	*v* 2 *t*	8.93	1507	*v* 1 *g*	9.48	1784	*b* 3 *v* 4 *d*	8.52
0679	*d* 3 *v* = *e*	9.29	1133	*v* = *t*	9.11	1517	*c* 3 *v* 2 *e*	9.26	1787	*b* 3½ *v* 4 *d*	8.55
0684	*k* 2 *v* 1 *l*	10.43	1134	*t* 2 *v* 4 *g*	9.26	1527	*b* 4 *v* 4 *d*	8.57	1793	*b* 3 *v* 5 *d*	8.48
0696	*m* 3 *v* = *s*	10.94	1140	*g* 3 *v* 3 *k*	9.83	1537	*v* 3 *b*	7.94	1812	*b* 1 *v*	8.30
0725	*s* 5 *v*	11.39	1152	*k* 3 *v* 3 *l*	10.32	1540	*v* 5 *b*	7.76	1824	*b* 3 *v* 5 *d*	8.48
1936	*k* 2½ *v* 2½ *h*	10.31	1158	*k* 3 *v* 2 *m*	10.44	1549	*a* 5 *v* 5 *b*	7.80	1843	*d* 3 *v* 1 *c*	9.08
1048	*f* 2 *v* 3 *g*	9.35	1168	*m* 4 *v* = *r*	11.03	1566	*v* 3½ *b*	7.90	1847	*c* 2 *v* 3 *g*	9.31
1063	*b* 3 *v* 5 *d*	8.48	1342	*v* 2 *b*	8.03	1576	*v* 2½ *b*	7.99	1856	*g* 2 *v*	9.75
1067	*b* 2 *v* 5 *d*	8.42	1348	*b* 2½ *v* 4 *u*	8.46	1723	*m* 2 *v*	10.85	1860	*g* 3 *v* 3 *k*	9.83
1070	*b* 1 *v*	8.30	1357	*b* 5 *v* 3 *u*	8.62	1727	*m* 3 *v*	10.94	1865	*g* 2 *v* 5 *k*	9.72
1074	*v* 2½ *b*	7.99	1363	*v* 1 *d*	8.84	1731	*m* 3 *v*	10.94	1873	*k* 2 *v* 3 *h*	10.27
1075	*v* 3 *b*	7.94	1375	*t* 1 *v* 2 *c*	9.20	1743	*v* = *k*	10.09	1889	*m* 2 *v*	10.85
1077	*v* 3 *b*	7.94	1377	*c* 2 *v* 3 *g*	9.31	1745	*v* 1 *k*	10.00			

W Herculis: The approximate magnitudes of the comparison stars have been determined by estimation, with the exception of *a*, *l*, and *m*, which have been taken from the *A. H. C. O.*: *a*(A.S.V. 1)7.77, *b*(2)8.65, *c*(4)8.56, *d*(7)9.03, *e*(9)9.42, *f*(16)10.33, *g*(14)10.00, *h*(18)10.73, *j*(19)11.28, *k*(20)11.78, *l*(22) 11.90, *m*(24)12.16. The value of the step is 0.10 for the 8th magnitude, 0.11 for the 9th, 0.13 for the 10th, and 0.16 for the 11th. The average value of the period 279.5 is confirmed. The maximum (8.05) occurred at 2420946. It is well determined. The minimum (13.10) occurred at 2421096. It is not so well marked as the maximum. The formula, where x is counted from the maximum is:

$$\begin{aligned} \text{Mag} = {} & 10.65 - 2.33 \sin(x + 75^\circ) \\ & -0.12 \sin(2x + 114^\circ) - 0.19 \sin(3x + 111^\circ) \\ & -0.08 \sin(4x + 150^\circ) - 0.04 \cos 6x \end{aligned}$$

0338	*f* 2 *v* 3 *j*	10.7	0679	*c* = *v* 2 *b*	8.5	1075	*m* 3 *v*	12.7	1459	*e* 2½ *v* 3 *g*	9.7
0342	*v* 1 *h*	10.6	0694	*c* 2 *v* 3 *d*, *b* 1 *v*	8.8	1096	*m* 5 *v*	12.9	1473	*v* 2 *e*	9.2
0352	*v* 2 *f*	10.1	0708	*c* 3 *v* 4 *e*	8.9	1134	*v* = 12.0	12.0	1474	*b* 4 *v* 1 *d*	8.9
0370	*v* 3 *e*	9.1	0723	*e* 1 *v*	9.5	1163	*v* 1 *j*	11.1	1484	*v* 1 *c*	8.5
0374	*b* 3½ *v* 4 *e*	9.0	0735	*e* 5 *v* 5 *h*	10.1	1170	*v* 2 *j*	11.0	1486	*a* 6 *v* 2 *c*	8.3
0381	*v* 3 *c*	8.2	0742	*g* 2 *v* 4 *j*	10.4	1184	*g* 3 *v* 3 *f*	10.2	1493	*a* 3 *v* 5 *b*	8.1
0391	*a* 1 *v*	7.9	0749	*v* 4 *k*, *v* 1 *j*	11.1	1190	*e* 5 *v* 3 *g*	9.8	1501	*a* 1½ *v*	7.9
0396	*v* 3 *d*	7.5	0770	*v* = 12.0	12.0	1194	*e* 4 *v* 3 *g*	9.8	1503	*a* 2 *v*	8.0
0399	*a* 2 *v* 5 *c*	8.0	0779	*m* 3 *v*	12.7	1207	*e* 3 *v* 7 *e*	8.8	1504	*a* 3 *v* 10 *b*	8.0
0417	*v* 3 *a*	7.5	0965	*c* 2 *v*, *b* 1 *v*	8.8	1317	*v* 3 *j*	10.8	1507	*a* 2 *v* 6 *b*	8.0
0438	*a* 9 *v* 2 *c*	8.4	0969	*c* 3 *v* 5 *d*, *b* 1 *v*	8.7	1342	*v* = ½(*l* + *m*)	12.0	1517	*a* 1½ *v* 7½ *b*	7.9
0449	*c* 3 *v* 5 *e*	8.9	0977	*c* 3 *v* 1 *d*	8.8	1348	½(*l* + *m*) 4 *v*	12.8	1522	*a* 5 *v* 2 *b*	8.4
0468	*v* 1 *g*	9.5	0992	*d* 1 *v* 4 *e*	9.1	1357	½(*l* + *m*) 5 *v*	13.0	1537	*v* = *b*	8.6
0618	*f* 3 *v*	10.7	1000	*v* 2 *e*	9.2	1375	½(*l* + *m*) 6 *v*	13.1	1539	*b* 2 *v*	8.9
0627	*e* 3½ *v* 1 *h*	10.0	1012	*v* 4 *e*	9.0	1388	*v* = 12.0	12.0	1540	*c* 2 *v* 1 *b*	8.6
0649	*c* 2 *v*, *b* 1 *v*	8.8	1031	*f* 3 *v* 3 *h*	10.5	1429	*j* 2 *v*	11.6	1549	*d* 2 *v* 2 *e*	9.2
0654	*c* 3 *v* 3 *d*	8.8	1048	*h* 5 *v* 2 *j*	11.1	1450	*g* 3 *v* 2 *f*	10.2	1566	*e* 3 *v* 4 *f*	9.8
0661	*v* = *b*	8.6	1064	*v* 3 *k*	11.3	1457	*e* 1½ *v* 3 *g*	9.6			

T Aquilæ: The magnitudes of the comparison stars were determined in steps and converted into magnitudes by comparison with the *H. C.* values: *a*(*A.S.V.* 10)8.30, *b*(12)8.68, *c*(14)8.87, *d*(13)9.06 *e*(16) 9.51, and *f*(28)9.86. The value of a step is 0.11 mag. The change is irregular.

0342	*v* = *c*	8.87	0723	*a* 1½ *v* 4 *c*	8.46	1133	*c* 3 *v* 3 *e*	9.19	1566	*v* 2 *c*	8.65
0352	*a* 1 *v* 1 *c*	.58	0748	*d* 1 *v* 3 *e*	9.17	1158	*a* 3 *v* 1 *c*	8.73	1727	*v* 1½ *c*	.71
0361	*v* = *b*	.68	0749	*v* 1 *c*	8.76	1194	*d* 3 *v* 1 *e*	9.40	1732	*a* 3 *v* 2 *c*	.64
0375	*v* = *b*	.68	0751	*a* 3 *v* 2 *c*	8.64	1348	*v* = *c*	8.87	1745	*v* 1 *c*	.76
0381	*v* = *b*	.68	0770	*a* 3 *v* 3 *c*	8.59	1377	*a* 4 *v* 1½ *c*	8.71	1760	*v* = *c*	.87
0398	*v* = *c*	.87	0781	*a* 4 *v* 2½ *c*	8.65	1411	*v* = *d*	9.06	1767	*a* 3 *v* 1½ *c*	.68
0438	*a* 2 *v* 1 *c*	.68	0791	*a* 3 *v* 2 *c*	8.64	1435	*v* = *c*	8.87	1777	*a* 3 *v* 2 *c*	.64
0468	*a* 3 *v* 3 *c*	.59	1018	*v* 2 *f*	9.64	1459	*v* = *c*	8.87	1787	*c* 1 *v*	.98
0653	*v* 1 *c*	.76	1036	*d* 2½ *v*	9.33	1475	*a* 3 *v* 2 *c*	8.64	1793	*c* 1 *v*	.98
0664	*v* 1 *c*	.76	1067	*d* 2 *v* 3 *e*	9.24	1504	*a* 3 *v* 2 *c*	8.64	1824	*v* 1 *c*	.76
0679	*a* 3 *v* 2 *c*	.64	1111	*b* 2 *v* 3 *f*	9.15	1527	*b* ½ *v*	8.74	1843	*v* 2 *c*	.65
0699	*a* 3 *v* 3 *c*	.59	1126	*a* 3 *v* 2 *c*	8.64	1547	*v* 1 *c*	8.76	1873	*v* = *c*	.87

TT Cygni: The comparison stars were: *a*(*A.S.V.* 2) 5.89, *b*(5)6.97, *c*(14)7.65, *d*(18)8.06, *e*(26)8.18, *f*(20)8.43. These are the *H. C.* magnitudes with the exception of *d* and *e* which were determined here by comparisons. The value of the step is 0.115 mag. The variation appears to be irregular.

0344	*b* 5 *v* = *c*	7.6	0646	*v* = *c*	7.6	0807	*b* 2 *v*	7.2	1173	*v* = *c*	7.7
0357	*b* 1½ *v* 2 *c*	7.3	0663	*b* 3 *v* 3 *c*	7.3	0979	*b* 3 *v* 1 *c*	7.3	1174	*c* 1½ *v* 3 *e*	7.8
0371	*a* 4 *v* 5 *d*	6.9	0679	*b* 3 *v* 3 *c*	7.3	1036	*b* 3 *v* 2½ *c*	7.3	1174	*v* = *d*	8.1
0381	*b* 2 *v* 3 *c*	7.2	0696	*c* 3 *v* 1½ *d*	7.9	1070	*b* 4 *v* 3 *c*	7.4	1486	*b* 4 *v* 2 *c*	7.4
0396	*b* = *v*	7.0	0708	*b* 4 *v* 3 *c*	7.4	1111	*v* 1 *c*	7.5	1502	*b* 5 *v* 1 *c*	7.5
0424	*b* 3 *v* 3 *c*	7.3	0725	*b* 3 *v* 1 *c*	7.5	1133	*b* 3 *v* 3½ *c*	7.3	1511	*b* 3 *v* 2 *c*	7.4
0449	*b* 5 *v* 5 *c*	7.3	0736	*b* 4 *v* 3 *c*	7.4	1158	*b* 3 *v* 4 *c*	7.3	1522	*b* 4 *v* 3 *c*	7.4
0458	*c* 1 *v* 5 *e*	7.7	0748	*b* 5 *v* 1 *c*	7.5	1202	*b* 4 *v* 3 *c*	7.4	1539	*v* = *c*	7.6
0475	*c* 2 *v* 5 *d*	7.8	0753	*b* 3 *v* = *c*	7.5	1348	*b* 5 *v* 2 *c*	7.5	1558	*b* 4 *v* 3 *c*	7.4
0506	*v* 3 *c*	7.3	0774	*b* 3 *v* 3 *c*	7.3	1411	*c* 2 *v*	7.9	1568	*b* 5 *v* 3 *c*	7.4
0646	*b* 5 *v* 3 *d*	7.7	0784	*b* 3 *v* 3 *c*	7.3	1459	*b* 1½ *v*	7.1	1758	*b* 2 *v* ½ *c*	7.5

W Vulpeculæ: The comparison stars were: *a*(*A.S.V.* 13)8.13, *b*(29)8.39, *c*(23)8.65, *d*(34)8.98, *e*(35)9.18, *f*(44)9.46, *g*(42)9.89, *h*(48)10.43. *a*, *d*, *e*, *g*, and *h* have been photometrically determined at the *H. C. O.* *b*, *c*, and *f* have been determined by interpolation. The value of the step is 0.10 mag. The following maxima have been observed: 0800 (8.3), 1040 (8.3), 1540 (8.5), 1800 (8.6), but they are rather uncertain. Subsidiary maxima occurred about 0383 (8.5) and 1160 (8.6). The following minima have been observed: 0445 (9.7), 0680 (9.6), 1475 (9.5), 1907 (10.1). Subsidiary minima occurred about 1110 (9.5), and 1365 (10.2). The variation of this star is rather irregular. The period was obtained by comparing with the maximum observed by BIESBROECK is 1905 (2417017). The formula is: 2421545 + 251E. The minimum occurs on an average 145 days after the maximum.

0344	*c* 2 *v* 3 *d*	8.8	0424	*c* 1 *v*	9.3	0653	*b* 3 *v* 4 *d*	8.6	0708	*v* = *e*	.2
0355	*c* 1½ *v* 2 *d*	.8	0445	*e* 5 *v*	.7	0664	*d* 1 *v* 2½ *e*	9.0	0722	*d* 2 *v* 3 *g*	.3
0370	*c* 1 *v* 3 *d*	.7	0446	*e* 5 *v* 2 *f*	.4	0679	*e* 3 *v* 2 *g*	.6	0736	*d* 1 *v* 2 *e*	.0
0381	*b* 1 *v* 2 *c*	.5	0465	*d* 3 *v*	.3	0696	*d* 3 *v* 3 *f*	.2	0748	*b* 5 *v* 3 *d*	8.8
0395	*c* 1 *v* 2 *d*	.8	0488	*e* 1 *v*	.3	0708	*d* 3 *v* 4 *g*	.4	0760	*b* 2 *v* 1 *e*	.6

0774	a 3 v 5 d	.4	1180	b 3 v 3 d	.7	1484	v = d	.0	1781	b 3 v 2 d	.7
0784	b 1 v 5 d	.5	1207	d 3 v 2 e	9.1	1493	b 4 v 2½ d	8.8	1787	b 2 v 3 d	.6
0799	a 5 v 3 b	.3	1239	v 2 f	.3	1502	a 5 v 4 d	.6	1815	b 2 v 2 d	.7
1040	a 3½ v 2 b	.3	1348	e 3 v 5 g	9.5	1511	b 3 v 4 d	.6	1827	v 1 d	.9
1063	b 3 v 2 d	.7	1363	g 4 v 3 h	10.2	1520	b 2 v 3 d	.6	1843	d 2 v 3 f	9.2
1075	b 4 v 2 d	.8	1377	e 4 v 1 g	9.8	1532	b 2 v 5 d	.6	1847	e 1 v 2 g	.4
1111	c 2½ v 3½ g	9.5	1384	d 1½ v	.1	1547	b 1 v	.5	1860	v 1 g	.8
1113	d 3 v 2 f	.3	1388	v = d	.0	1565	c 3 v 2 d	.9	1867	e 3 v 4 g	.5
1126	v 1 d	8.9	1411	v = d	.0	1581	d ½ v	9.0	1873	d 3 v 3 f	.2
1133	b 3 v 2 d	.7	1411	b 4 v 4 f	8.9	1732	b 2 v 3 d	8.6	1879	f 3 v = g	.8
1134	b 4 v 2 d	.8	1429	v 1½ d	.8	1743	b 3½ v 2½ d	.7	1889	g 1 v	10.0
1153	b 3 v 3 d	.7	1450	d 1 v	9.1	1760	v 1 d	.9	1906	g 2 v 4 h	.1
1168	b 3 v 1½ d	.8	1475	c 3 v 3 g	.5	1767	v 2 d	.8	1913	g 2 v	.1
									1928	e 5 v 3 f	9.4

SV Cygni: The magnitudes of the comparison stars are as follows: *a*(*A.S.V.* 5)6.64, *b*(6)7.96, *c*(16)8.21, *d*(17)8.31, *e*(18)8.41, *f*(26)8.83, *g*(36)9.30, *h*(47)9.90. *a*, *c*, *g*, and *h* have been photometrically determined at the *H. C. O.*, the others here by comparison. The value of a step has been assumed to be 0.10 mag. No regular variation appears.

0347	d 1 v 4 h	8.6	0538	d 1½ v	8.5	0899	f 2 v	9.1	1239	v = d	8.3
0349	d 5 v 5 h, c 1½ v	8.7	0646	v 2 f	8.6	0979	d 3 v 3 f	8.6	1255	c 2 v 3 f	8.5
0356	c 3 v 5 h	8.8	0663	f 2 v 5 h	9.1	1036	c 3 v 4½ f	8.5	1357	d 1½ v 3 f	8.5
0364	c 2 v 6 h, d 1½ v	8.6	0696	c 4 v 3 f	8.6	1067	c 3 v 2 f	8.7	1411	c 3 v 6 f	8.5
0374	d 4 v 1 h	9.1	0717	b 3 v	8.3	1083	f 2 v	9.0	1459	d 1 v 3½ f	8.4
0387	d 2 v 2 f	8.6	0735	d 3 v 3 f	8.6	1132	d 2½ v 5 f	8.5	1484	d 4 v 4 f	8.6
0395	d 3 v, f 1 v	8.8	0752	d 1 v 1 e	8.4	1153	d 1 v	8.4	1508	d 2½ v 4 f	8.5
0399	e 2 v 2 f	8.6	0775	d 2 v 4 f	8.5	1170	d 2 v 1½ e	8.4	1522	c 6 v 3 f	8.7
0449	d 1 v 2½ f	8.5	0785	d 3 v 4 f	8.5	1183	d 1 v	8.4	1539	d 3 v 3 f	8.6
0475	v = d	8.3	0804	d 1 v 5 f	8.4	1192	d 2 v 3 f	8.5	1566	d 2 v	8.5
0516	c 2 v 3 d	8.3	0892	d 3 v 3 h	9.1	1202	v = d	8.3	1578	d 3 v 3 f	8.6

R Delphini: The *H. C.* comparison stars were used with the following three additions: *k′*(*A.S.V.* 10)9.75, *l′*(25)10.02, and *q′*(32)14.86. The step was assumed to be 0.10 mag. The maximum (8.59) occurred at 2421531. The minimum (about 13.6) occurred about 2421413. It occurs about 166 days after maximum. The average period is 284.2 days. The formula, where *x* is counted from maximum, is: Mag. = 11.21 − 2.43 sin $(x + 82°)$ + 0.36 sin $(2x - 51°)$ + 0.07 sin $(3x + 153°)$.

0344	l′ 1 v = m	10.4	0684	f 2 v 2 A	8.6	0801	. . . . .	13.0	1457	v = ½(r + q′)	12.1
0355	B 3 v 1 k′	9.5	0707	B 4 v 1 k′	9.4	1040	p 2 v 3 q′	11.7	1473	m 5 v 3 n	10.6
0370	v 1 B	8.9	0722	v 1 k′	9.6	1049	p 3 v	11.9	1475	v = o	11.0
0374	v 2 B	8.8	0722	v 3 l	9.5	1067	r 3 v	12.6	1484	v = m	10.1
0387	A = v 3 B	8.8	0736	l′ 4 v	10.5	1070	q′ 3½ v	12.2	1493	v 2 l	9.6
0395	v 3 B	8.7	0746	m 5 v	10.6	1077	r 5 v = t	12.9	1502	B 2 v	9.2
0399	v 3 A	8.6	0746	n 3 v 5 q	11.2	1080	r 5 v 5 t	12.7	1511	f 2 v 3 A	8.5
0405	v = B	9.0	0750	o 5 v 3 q	11.5	1096	. . . . .	12.7	1520	f 3 v 2 B	8.7
0421	v 2 k′	9.5	0750	v 3½ p	11.3	1113	. . . . .	>12.3	1532	v = f	8.3
0446	l′ 3 v 3 m	10.1	0770	q 2 v	12.0	1202	m 2 v	10.3	1537	f 2 v 3 B	8.6
0653	v 4 B	8.6	0779	q′ 4 v	12.2	1206	m 1 v	10.2	1549	v = B	9.0
0667	v 3 A	8.6	0799	. . . . .	12.5	1394	t 4 v	13.5	1566	B 2 v 4 k	9.2
									1576	v 2 k′	9.5

R Sagittæ: The *H. C.* comparison stars were used. Their degree of brightness was observed in steps and converted into magnitudes by aid of the *H. C.* values: *a* 8.12 (this is the *H. C.* mag.), *b* 8.26, *c* 8.62, *d* 8.94, *e* 9.20, *f* 9.61, and *g* 9.98. The value of a step is 0.083 mag. Maximum (8.52) occurred at 2121159, a secondary minimum (9.02) at 1178, a secondary maximum (8.81) at 1188, and the principal minimum (9.55) at 1140. The period determined from 25 individual determinations of these epochs was 70.9 days, with which value the observations were referred to one period. The period appears to be irregular. Its average value is 70.51 days. The formula is: Mag. = 8.94 − 0.26 sin $(x + 40°)$ − 0.28 sin $(2x + 105°)$ − 0.04 sin $(3x + 166°)$ + 0.05 cos $4x$ − 0.01 sin $5x$ − 0.03 cos $6x$.

0344	*d* 1 *v* 3 *e*	9.07	0784	*f* 3 *v* 3 *g*	9.80	1220	*c* 1 *v* 2 *d*	8.73	1824	*c* 1½ *v* 1½ *d*	8.78
0355	*d* 1 *v* = *c*	9.12	0788	*f* 1 *v* 3 *g*	9.70	1416	*v* = *e*	9.20	1827	*c* 2 *v* 2 *e*	8.91
0370	*c* 1½ *v* 2 *d*	8.75	0791	*e* 4 *v* 2 *f*	9.47	1432	*v* = *d*	8.94	1828	*c* 2 *v* 3 *d*	8.75
0375	*v* 1 *c*	8.54	0799	*c* 3 *v* 2 *d*	8.81	1435	*v* 1 *c*	8.54	1830	*c* 2 *v* 2 *d*	8.78
0381	*b* 5 *v* 1 *c*	8.56	0801	*c* 2 *v* 3 *d*	8.75	1450	*c* 1½ *v* 1½ *d*	8.72	1838	*v* 1 *d*	8.86
0395	*d* 2½ *v* 1 *e*	9.13	0807	*c* 1 *v* 3 *d*	8.70	1459	*d* 3 *v* 1 *e*	9.13	1843	*v* ½ *d*	8.90
0403	*c* 3 *v* 2 *d*	8.81	1036	*d* 2 *v* 1 *e*	9.13	1473	*c* 1 *v* 2 *d*	8.73	1844	*c* 3½ *v* 1½ *d*	8.84
0424	*v* = *e*	9.20	1049	*v* = *d*	8.94	1475	*c* 1 *v* 1½ *d*	8.75	1847	*v* = *e*	9.20
0446	*c* 2 *v* 3 *d*	8.75	1063	*e* 1½ *v* 3 *f*	9.34	1484	*d* 1 *v* 1½ *e*	9.04	1860	*c* 3 *v* 1 *d*	8.86
0465	*d* 1 *v* 1 *e*	9.07	1064	*e* 3 *v* 3 *f*	9.40	1488	*e* 1 *v* 3 *f*	9.30	1864	*b* 1 *v* 2 *c*	8.38
0506	*e* 2 *v* 5 *f*	9.32	1070	*f* 1 *v* 3 *g*	9.70	1492	*e* 2 *v* 4 *f*	9.34	1865	*v* = *b*	8.26
0653	*v* = *c*	8.62	1075	*v* = *e*	9.20	1501	*c* 3 *v* 1 *d*	8.86	1867	*a* 3 *v* 2 *b*	8.20
0664	*v* = *c*	8.62	1076	*d* 2 *v* 3 *f*	9.21	1504	*v* ½ *c*	8.58	1870	*v* 1 *c*	8.54
0684	*d* 1 *v* 2 *e*	9.03	1077	*d* 2 *v* 1 *e*	9.13	1507	*v* 1 *c*	8.54	1873	*c* 1 *v* 3 *d*	8.70
0699	*v* 2 *e*	9.03	1083	*c* 2 *v* 1½ *d*	8.80	1508	*c* 2 *v* 3 *d*	8.75	1874	*b* 2 *v* 1 *c*	8.50
0707	*v* = *e*	9.20	1084	*c* 2 *v* 2 *d*	8.78	1520	*b* 3 *v* 1 *c*	8.53	1875	*c* 1½ *v*	8.74
0711	*e* 2 *v* 3 *f*	9.36	1096	*c* 1 *v* 3 *d*	8.70	1525	*c* 2 *v* 1½ *d*	8.80	1879	*c* 2 *v* 1½ *d*	8.80
0716	*e* 2 *v* 3 *f*	9.36	1111	*d* 1 *v* 2 *e*	9.03	1527	*v* = *d*	8.94	1889	*d* 1 *v*	9.02
0725	*c* 3 *v* 1 *d*	8.86	1120	*d* 1½ *v* 2½ *e*	9.04	1532	*v* ½ *e*	9.16	1894	*c* 2 *v* 3 *d*	8.75
0729	*c* 2 *v* 1 *d*	8.83	1126	*v* = *d*	8.94	1539	*c* 1 *v* 2 *d*	8.73	1896	*c* 1 *v* 2 *d*	8.73
0735	*v* 1 *c*	8.54	1134	*e* 1 *v* 3 *f*	9.30	1547	*c* 3 *v* 2 *d*	8.81	1899	*c* 2 *v* 1½ *d*	8.80
0741	*v* 1½ *e*	9.07	1140	*f* 3 *v* 1½ *g*	9.86	1565	*v* = *e*	9.20	1900	*c* 1½ *v* 2½ *d*	8.74
0746	*c* 4 *v* 2 *d*	8.83	1157	*c* 1½ *v* 1½ *d*	8.78	1576	*c* 2 *v* 3 *d*	8.75	1905	*c* 3 *v* 1 *d*	8.86
0748	*v* = *d*	8.94	1163	*c* 1½ *v* 2½ *d*	8.74	1581	*b* 2 *v* 3 *c*	8.40	1906	*c* 2 *v* 2 *d*	8.78
0749	*c* 4 *v* 1 *d*	8.88	1170	*c* 3½ *v* 1½ *d*	8.84	1783	*e* 3½ *v* 2 *f*	9.46	1907	*c* 2 *v* 1½ *d*	8.80
0750	*c* 4 *v* 1 *d*	8.88	1181	*c* 3 *v* 1½ *d*	8.83	1787	*d* 3 *v* 1 *e*	9.14	1913	*d* 2 *v* 1 *e*	9.11
0751	*c* 3 *v* 1½ *d*	8.83	1184	*c* 4 *v* 2 *d*	8.83	1793	*c* ½ *v* 3 *d*	8.67	1919	*e* 1 *v* 3 *f*	9.30
0770	*d* 1 *v* 1½ *e*	9.08	1194	*c* 5 *v* 1 *d*	8.89	1796	*c* 1 *v* 3 *d*	8.70	1920	*e* 3 *v* 3 *f*	9.40
0777	*e* 1 *v* 4 *f*	9.28	1206	*f* 2 *v* 1 *g*	9.86	1815	*c* 2 *v* 1 *d*	8.83	1925	*e* 4 *v* ½ *f*	9.56
0779	*e* 2 *v* 4 *f*	9.34	1207	*e* 2 *v* 3 *f*	9.36	1820	*d* 1 *v*	9.02	1935	*v* = *c*	8.62
									1944	*c* ½ *v*	8.66

U Cygni: The magnitudes of the comparison stars were observed in steps and converted into magnitudes by aid of the *H. C.* values: *a*(A.S.V. 6)6.99, *b*(7)7.30, *c*(10)7.82, *d*(12)8.04, *e*(13)8.36, *f*(24)9.01, *g*(27)9.33. The value of a step is 0.1 mag. Maximum (6.8) occurred at 2421790. For about two months the brightness did not change one step. Minimum (8.9) occurred at 2421575: 250 days after maximum. The average period is 464.7 days. It appears to be variable. The formula for finding the magnitude (x is counted from the maximum) is:

$$
\begin{aligned}
\text{Mag.} = 7.80 &- 0.91 \sin (x + 92°) \\
&+ 0.03 \sin (2x + 45°) - 0.13 \sin (3x + 67°) \\
&- 0.06 \sin (4x + 149°) + 0.04 \sin (5x + 146°)
\end{aligned}
$$

0347	v 2 c	7.6	0799	v 3 c	7.6	1348	v 1 d	6.9	1732	v 2 a	6.8
0362	v 2 b	7.1	0887	v 3 d	6.7	1377	a 5 v 5 c	7.4	1734	a 1 v 3 b	7.1
0417	v 5 a	6.5	0901	v 3 c	7.5	1384	a 3½ v 5½ c	7.3	1743	v 3 a	6.7
0449	v 1 a	6.9	0903	b 3 v 4 c	7.5	1432	b 3 v 3 c	7.6	1744	v 2 a	6.8
0475	v 4 c	7.4	1040	e 3 v 5 f	8.6	1457	c 3 v 2 e	8.1	1758	v 3 a	6.7
0506	v 3 c	7.5	1063	d 5 v 5 f	8.5	1474	d 2 v	8.2	1777	v 3 a	6.7
0538	v = c	7.8	1075	e 3 v 4 f	8.6	1486	c 2 v 3 e	8.0	1784	v 1 a	6.9
0646	f 1½ v 3 g	9.1	1075	d 5 v	8.5	1499	e 2 v 5 f	8.5	1796	v 2 a	6.8
0663	f 3 v 3 g	9.2	1132	f 1 v 5 g	9.1	1517	d 3½ v 5 f	8.4	1826	a 1 v	7.1
0696	d 4 v 4 f	8.5	1156	d 2 v 2 e	8.2	1532	d 3 v 3 e	8.3	1843	a 3 v 1 b	7.2
0709	d 3 v	8.3	1158	c 3 v 3 e	8.1	1549	d 3 v	8.3	1852	b 2 v 3½ c	7.5
0721	d 1 v = e	8.2	1170	v = c	7.8	1566	v = e	8.4	1862	b 2 v 4 c	7.5
0735	d 1 v, c 3 v	8.1	1183	v 2 c	7.6	1578	v 1 f	8.9	1870	b 3 v 2 c	7.6
0752	v 3 c	7.5	1198	v 3 c	7.5	1601	d 3 v	8.3	1894	b 3½ v 1½ c	7.7
0753	v = c	7.8	1207	b 3 v 4 c	7.6	1626	d 2½ v 2½ e	8.2	1913	c 1½ v	8.0
0775	b 5 v 2 c	7.7	1239	v 3 b	7.0	1640	c 3½ v 1 d	8.0	1920	c 1 v	7.9
0785	v 2 c	7.6	1255	a 3 v 5 c	7.3	1727	v = b	7.3			

S Delphini: The magnitudes of the comparison stars were observed in steps and converted into magnitudes by aid of the *H. C.* values: *a* 8.33, *b* 8.59, *c* 8.59, *d* 8.86, *e* 9.09, *f* 9.42, *g* 9.87, *h* 9.87, *k* 10.12, *l* 10.50, *m* 11.10, *n* 11.52, *p*(11.96). The value of the step is at 8.5: 0.068, at 9.5 : 0.087, at 10.5: 0.107, at 11.5 : 0.122. The maximum (8.8) occurred about 2421442. The minimum (10.9) about 2420772 (161 days after maximum). The value of the period is 277 days. The formula is:

$$\text{Mag.} = 9.59 - 0.94 \sin(x + 72°) + 0.27 \sin(2x + 22°) + 0.10 \sin(3x + 156°) + 0.05 \sin(4x - 68°) - 0.06 \sin 5x$$

0356	a 3 v 1 c	8.5	0749	l 1 v	10.6	1180	c 4 v 2 d	8.8	1549	v = f	9.4
0371	c 2 v	8.7	0751	l 2 v 5 n	10.8	1194	c 3 v 2 d	8.7	1558	h 2 v	10.1
0382	d 2 v	9.0	0760	l 3 v 3 m	10.8	1207	d 2 v 1 e	9.0	1565	h 1½ v 3 g	9.9
0395	e 1 v = f	9.3	0784	l 2 v 1 m	10.9	1239	c 5 v 2 d	8.8	1568	k 1 v 1 l	10.3
0399	v = f	9.4	0799	k 3 v 3 l	10.3	1394	d 2 v 2 e	9.0	1576	h 3 v 3 k	10.0
0417	v 1 h	9.8	1040	m 4 v 3 n	11.2	1411	c 2 v 3 d	8.7	1578	l 2 v	10.7
0434	h 1 v 1 k	10.0	1049	l 3 v 5 m	10.7	1432	c 3 v 1½ d	8.8	1767	c 3 v 1 f	9.3
0465	v 1 l	10.4	1067	v = l	10.5	1459	d 3 v 2 e	9.0	1781	c 3 v 2 f	9.3
0475	v 1 l	10.4	1075	h 3 v 1 k	10.1	1473	e 2 v 4 f	9.2	1796	c 2 v 3 f	9.2
0488	h 3 v 1 l	10.3	1077	l 2 v 3 m	10.7	1475	d 3 v 1 f	9.3	1820	f 2 v 3 g	9.6
0664	c 2 v 2 d	8.7	1080	h 2 v 2 k	10.0	1486	e 3 v 2 f	9.3	1827	f 2 v 3 g	9.6
0691	d 3 v = f	9.3	1096	e 1 v 2 f	9.2	1493	e 3 v 2½ f	9.3	1844	f 4 v 1 g	9.8
0709	f 4 v 2 g	9.7	1113	v = e	9.1	1502	e 4 v 1½ f	9.3	1847	h 2 v 4 l	10.1
0717	v 3 h	9.6	1125	e 2 v 3 f	9.2	1507	e 1 v 4 f	9.2	1860	h 1½ v 1 k	10.0
0725	h = v 3 k	9.8	1133	e 3 v 1 f	9.3	1517	e 3 v 3 f	9.3	1865	h 1 v 1 k	10.0
0736	l 2 v	10.7	1152	d 2 v 3 e	9.0	1525	e 3 v 2 f	9.3	1874	k 2 v 1 l	10.4
0746	l 2 v 3 m	10.7	1158	c 3 v = d	8.8	1532	f 2 v	9.6	1905	k 2 v 2 l	10.3
0748	v 3 p	11.6	1170	c 2 v 1 d	8.8	1546	v = ½(k + l)	10.3	1913	k 3 v 3 l	10.3
									1920	k 2 v 2 l	10.3

R Vulpeculae: The comparison stars are: *a′*(A.S.T. 2) 7.08, *b*(1)7.23, *c′*(3)7.59, *d* 7.79, *e* 8.07, *f* 8.17, *j*(4)8.77, *g′*(5)9.00, *k*(7)9.34, *l*(11)9.54, *m*(19)9.79, *A*(23)9.99, *p*(52)10.34, *p′*(24)10.39, *q*(29)10.63, *r*(31)10.86, *r′*(26) 11.02, *s*(10)11.36, *t*(57)11.84, *u*(70)12.47. They have been photometrically observed at the *H. C. O.* with the exception of *a′* which has been estimated here. The value of the step is about a tenth of a magnitude.

Maximum (7.3) occurred at 2421116. The minimum (12.5) falls midway between two maxima. Maximum is well defined, minimum less so. The period 136.8 is confirmed. Mr. Walter J. Gill wrote in 1895 that the light curve was very regular. At present kinks occur both before and after maximum: particularly from 19 to 38 days after maximum, when the fall in brightness is checked. At one of the individual maxima the star was not observed to be above magnitude 8.0, and at one of the minima not below 11.7. The average variation is as follows:

$$\begin{aligned}\text{Mag.} = 9.98 - 2.56 \sin (x + 95°) \\ +0.12 \sin (2x + 132°) - 0.04 \cos 3x \\ -0.22 \sin (4x + 77°) - 0.14 \sin 5x + 0.10 \cos 6x\end{aligned}$$

The principal terms are multiplied by cousinus of the angle which indicates approximate symmetry.

0347	$s\ 4\ v$	11.8	0784	$t\ 3\ v$	12.1	1432	$g\ 3\ v\ 1\tfrac{1}{2}\ r$	10.8	1815	$g\ 1\ v$	8.9
0399	$m\ 3\ v$	10.9	0785	$t\ 5\ v$	12.3	1450	$s\ 2\tfrac{1}{2}\ v\ 1\tfrac{1}{2}\ t$	11.7	1820	$v\ 1\ k$	9.2
0417	$g'\ 5\ v\ 7\ l$	9.2	0800	$A\ 3\ v\ 2\ r$	10.5	1459	$p\ 5\ v\ 3\ t$	11.3	1824	$v = k$	9.3
0437	$c'\ 10\ v\ 6\ g'$	8.5	1040	$u\ 2\ v$	12.7	1475	$A\ 1\ v\ 2\ p'$	10.1	1826	$k\ 2\ v\ 3\ l$	9.3
0449	$c'\ 2\ v\ 5\ g'$	8.0	1049	$v = u$	12.5	1484	$l\ 1\ v\ 4\ m$	9.6	1828	$k\ 1\ v\ 1\ l$	9.5
0468	$g'\ 7\ v\ 3\ l$	9.4	1070	$r'\ 3\ v\ 5\ t$	11.3	1492	$g'\ 5\ v\ 2\ k$	9.2	1830	$l\ 2\ v\ 2\tfrac{1}{2}\ m$	9.7
0475	$v = m$	9.8	1075	$m\ 2\ v\ 3\ p'$	10.0	1501	$g = v\ 3\ g'$	8.7	1838	$r\ 3\ v\ 7\ s$	11.0
0663	$m\ 2\tfrac{1}{2}\ v = p'$	10.2	1080	$j'\ 6\ v\ 1\ l$	9.5	1507	$c'\ 5\ v\ 5\ j$	8.2	1843	$t\ 1\ v$	11.9
0691	$c'\ 5\ v$	8.1	1084	$k\ 2\tfrac{1}{2}\ v\ 3\ l$	9.4	1508	$c'\ 7\ v\ 5\ j$	8.3	1844	$t\ 2\ v$	12.0
0709	$c'\ 2\ v$	7.8	1096	$g\ 1\ v\ 3\ g'$	8.8	1517	$c'\ 2\ v$	7.8	1845	$t\ 2\ v$	12.0
0717	$a'\ 5\ v\ 7\ g'$	7.9	1111	$b\ 1\ v$	7.3	1520	$b\ 3\ v\ 1\tfrac{1}{2}\ c'$	7.5	1860	$t\ 5\ v$	12.3
0725	$g\ 2\ v = j'$	9.0	1113	$a'\ 5\ v\ 3\ c'$	7.4	1520	$c'\ 2\ v$	7.8	1889	$s\ 3\ v\ 2\ t$	11.6
0729	$j\ 5\ v\ 2\ k$	9.2	1125	$b\ 2\ v$	7.4	1532	$c'\ 2\ v$	7.8	1891	$r\ 1\ v$	11.0
0729	$k\ 4\ v\ 3\ l$	9.4	1126	$b\ 2\ v\ 2\ c'$	7.4	1539	$v\ 3\ g$	8.5	1896	$r\ \tfrac{1}{2}\ v$	10.9
0735	$g'\ 10\ v\ 10\ m$	9.1	1134	$v\ 1\ g$	8.7	1546	$j\ 2\ v$	9.0	1899	$m\ 2\ v$	10.0
0742	$l\ 2\ v\ 2\ m$	9.7	1138	$g'\ 1\ v\ 6\ k$	9.1	1558	$k\ 5\ v\ 2\ l$	9.5	1900	$l\ 4\ v\ 1\tfrac{1}{2}\ m$	9.7
0746	$A\ 1\ v\ 3\ r$	10.2	1152	$v\ 1\ m$	9.7	1566	$r\ 2\ v$	11.1	1905	$k\ 3\ v\ 1\ l$	9.5
0747	$m\ 3\ v\ 5\ r$	10.2	1158	$t\ 7\ v\ 3\ s$	11.2	1568	$r\ 5\ v\ 5\ s$	11.1	1906	$k\ 1\ v\ 3\ l$	9.4
0749	$r' = r\ 3\ v$	11.2	1163	$t\ 3\tfrac{1}{2}\ v$	12.2	1576	$v = t$	11.8	1907	$k\ 1\tfrac{1}{2}\ v\ 2\ l$	9.4
0750	$r\ 3\ v\ 4\ t$	11.3	1170	$s\ 7\ v$	12.1	1601	$v = \tfrac{1}{2}(r + r')$	10.9	1919	$e\ 2\ v\ 3\ f$	8.2
0751	$r\ 3\ v\ 4\ t$	11.3	1220	$l\ 3\ v\ 3\ m$	9.7	1784	$e\ 2\ v\ 1\ f$	8.3	1920	$f\ 2\ v\ 4\ g$	8.6
0751	$r'\ 3\ v\ 3\ s$	11.2	1239	$b\ 3\ v\ 3\ g'$	8.1	1787	$d\ 1\ v\ 1\ e$	7.9	1925	$e\ 1\ v\ 2\ f$	8.2
0753	$r\ 4\ v$	11.3	1394	$v\ 1\ g$	8.7	1793	$d\ 1\ v$	7.9	1928	$c'\ 3\ v\ 3\ c$	7.8
0758	$r'\ 5\ v\ 2\ s$	11.3	1416	$k\ 3\ v\ 2\ l$	9.5	1796	$v\ 1\ d$	7.7	1935	$e\ 3\ v\ 2\ f$	8.3

TW Cygni: The *H. C.* comparison stars were used. The value of the step is 0.095. The light curve is regular but at a different level in different periods. The maximum was 9.9. The formula is: 2420712 + 339E. The minimum was about 13.5.

0349	$v\ 2\ h$	11.0	0712	$e\ 2\ v\ 4\ f$	10.4	1075	$e\ 4\ v\ 2\ f$	10.5	1481	$n\ 3\ v$	12.8
0358	$c\ 2\ v$	10.5	0746	$v = f$	10.7	1077	$c\ 3\ v\ 3\ f$	10.5	1492	$n\ 5\ v$	13.0
0371	$c\ 2\ v = d$	10.3	0747	$c\ 3\ v$	10.7	1096	$g\ 3\ v\ 3\ h$	11.1	1507	$n\ 6\ v$	13.1
0387	$d\ 1\ v\ 1\ e$	10.2	0750	$g\ 3\ v\ 5\ h$	11.0	1111	$l\ 1\ v\ 3\ m$	12.1	1539	$n\ 5\ v$	13.0
0396	$v = d$	10.1	0751	$e\ 3\ v\ 3\ f$	10.5	1126	$v = m$	12.4	1767	$v\ 1\ f$	10.6
0427	$f\ 2\ v\ 2\ g$	10.8	0753	$e\ 4\ v\ 4\ f$	10.5	1132	$l\ 3\ v\ 1\ m$	12.3	1768	$f\ 4\ v\ 2\ g$	10.9
0432	$g = v\ 2\ h$	11.0	0758	$v = f$	10.6	1394	$v\ 1\ c$	9.8	1770	$g\ 3\ v\ 2\ h$	11.1
0453	$h\ 3\ v\ 3\ n$	11.8	0770	$g\ 2\ v\ 5\ h$	11.0	1411	$c\ 3\ v\ 2\ f$	10.5	1783	$v = h$	11.2
0656	$h\ 3\ v\ 3\ m$	11.8	0777	$g\ 5\ v\ 2\ h$	11.1	1416	$e\ 3\ v\ 2\ f$	10.5	1793	$l\ 2\ v\ 3\ m$	12.2
0663	$k\ 1\tfrac{1}{2}\ v = l$	11.8	0800	$v = n$	12.5	1432	$h\ 2\ v$	11.4	1796	$m\ 1\ v$	12.5
0691	$e\ 1\ v\ 2\ f$	10.4	1040	$c\ 2\ v\ 2\ d$	10.0	1450	$k\ 2\ v\ 1\ l$	11.9	1815	$n\ 2\ v$	12.7
0709	$b\ 3\ v\ 2\ c$	9.6	1063	$c\ 3\ v\ 1\ d$	10.1	1459	$v = n$	12.5	1820	$n\ 3\ v$	12.8
0723	$b\ 4\ v\ 2\ c$	9.7	1074	$g\ 3\ v\ 3\ h$	11.1	1475	$v = n$	12.5	1830	$v = n$	12.5
									1873	$v = r$	13.5

RU Cygni: The magnitudes of the *H. C.* comparison stars were determined in steps and converted into magnitudes by aid of the *H.C.* values: *a′*(*A.S.V.*3)7.08, *a* 7.55, *b* 7.82, *c* 8.09, *d* 8.38, *e* 8.75, *f* 8.90, *h* 9.12, *k* 9.37, and *l* 9.66. The value of the step is 0.064 mag. The following maxima were observed 0655(7.7,) 1071(7.3), 1531(7.3), 1970(7.9). The formula is: 2421075 + 441E (7.6). A minimum (9.7) was observed at 1852. The minimum (9.5) occurs 350 days after maximum. The period, the extent of the variation, and the shape of the light curve are irregularly variable. About 160, and 260 days after the principal maximum occurred a second (8.3), and a third (8.6) maximum. About 110, 210, and 350 days after maximum occurred a first (8.6), a second (9.0) and a third (9.5) minimum. The latter was the principal minimum and the brightness then increased in about 90 days to about 7.5.

0349	*b* 2½ *v* 4 *f*	8.2	0887	*e* 1 *v* 2 *f*	8.8	1457	*d* 3 *v* 1 *e*	8.7	1758	*v* 3 *e*	8.6
0361	*v* = *d*	8.4	0901	*d* 5 *v* 2 *e*	8.6	1474	*c* 4 *v* 3 *d*	8.3	1777	*d* 3 *v* 4 *e*	8.5
0374	*v* 3 *d*	8.2	1040	*a* 3 *v* 2 *b*	7.7	1476	*c* 3½ *v* 1 *d*	8.3	1787	*d* 3 *v* 3 *e*	8.6
0395	*v* 3 *e* = *f*	8.6	1067	*a′* 3 *v* 5 *a*	7.3	1493	*b* 1 *v* 3 *c*	7.9	1812	*e* 3 *v* 1½ *f*	8.8
0432	*v* = *e*	8.7	1070	*a′* 3 *v* 3 *a*	7.3	1517	*a′* 5 *v* 3 *a*	7.4	1820	*v* = *f*	8.9
0465	*f* 3 *v* 2 *h*	9.0	1076	*a′* 4 *v* 3 *a*	7.3	1546	*a′* 3 *v* 5 *a*	7.3	1827	*f* 3 *v* 3 *g*	9.1
0482	*h* 2 *v*	9.2	1109	*a′* 3 *v* 3 *c*	7.6	1566	*a* 4 *v* 3 *b*	7.7	1838	*h* 1½ *v* 1½ *k*	9.2
0486	*h* 3 *v*	9.3	1149	*b* 4 *v* 2 *d*	8.2	1575	*a* 2 *v* 3 *b*	7.7	1844	*h* 2½ *v* 1 *k*	9.3
0507	*h* 3 *v* 1 *k*	9.3	1170	*d* 3 *v* 2 *f*	8.7	1578	*b* 2 *v* 3 *d*	8.0	1852	*k* 3 *v* 5 *m*	9.6
0534	*f* 3 *v*	9.1	1188	*d* 4 *v* 1 *e*	8.7	1601	*v* 2 *b*	7.7	1862	*k* 2 *v* 4 *l*	9.5
0655	*a* 1 *v* 3 *b*	7.8	1192	*e* 1 *v* 2 *f*	8.8	1602	*c* 1 *v* 2 *d*	8.2	1870	*k* ½ *v*	9.4
0665	*c* 3 *v* 3 *d*	8.2	1217	*v* = *d*	8.4	1615	*b* 3 *v* 4 *c*	7.9	1880	*k* 1 *v* 4 *l*	9.4
0691	*v* = *d*	8.4	1223	*v* = *d*	8.4	1626	*d* 1 *v* 4 *e*	8.4	1907	*h* 1 *v* 2 *k*	9.2
0711	*d* 2 *v* 3 *f*	8.6	1239	*d* 3 *v* 5 *f*	8.6	1640	*d* 2 *v* 3 *e*	8.5	1913	*h* 3 *v* 3 *k*	9.3
0729	*f* 1 *v* 2 *h*	9.0	1255	*c* 1½ *v* 2 *d*	8.2	1661	*d* 3 *v* 2 *e*	8.6	1925	*d* 5 *v* 2 *e*	8.6
0747	*d* 3 *v* 3 *e*	8.6	1266	*c* 3 *v* 2 *d*	8.3	1722	*f* 2 *v* 1 *h*	9.0	1944	*d* 2 *v* 4 *e*	8.5
0761	*d* 3 *v* 3 *e*	8.6	1357	*c* 5 *v* 1½ *d*	8.3	1729	*v* = *h*	9.1	1959	*d* 3 *v* 5 *e*	8.5
0779	*v* = *d*	8.4	1377	*d* 2 *v* 3 *e*	8.5	1741	*f* 1 *v* 2 *h*	9.0	1970	*b* 2 *v* 3 *c*	7.9
0791	*b* 3 *v* 1 *c*	8.0	1384	*e* 2 *v* 3 *f*	8.8	1744	*d* 2 *v* 5 *e*	8.5	1976	*b* 3 *v* 3 *c*	8.0
0804	*c* 1 *v* 3 *d*	8.2	1416	*f* 2 *v* 2 *h*	9.0	1745	*d* 2 *v* 2 *e*	8.6			

RV Cygni: The magnitudes of the comparison stars: *a*(*A.S.V.* 1)5.62, *b*(3)6.87, *c*(5)7.48 and *d*(7)8.13 have been determined at the *H. C. O.* The value of one step is 0.111 mag. The observations are difficult because this star is so highly colored. There appears to be no regular variation.

0349	*b* 1½ *v* 1 *c*	7.2	0707	*b* 2½ *v* 4 *c*	7.1	1078	*b* 3 *v* 3 *c*	7.2	1432	*a* 3 *v* 3 *b*	6.3
0358	*b* 3 *v* 3 *c*	.2	0725	*c* 2 *v* 6 *d*	.6	1084	*v* = *b*	6.9	1457	*v* 2½ *b*	6.6
0362	*v* 3 *c*, *v* 1 *b*	0	0736	*b* 3 *v* 3 *c*	.2	1111	*v* 2 *b*	6.7	1474	*b* 1 *v* 2 *c*	7.1
0374	*b* 3 *v* 3 *c*	.2	0746	*b* 3 *v* 2 *c*	.2	1126	*a* 5 *v* 1 *b*	6.7	1484	*b* 1 *v* 4 *c*	7.0
0382	*b* 2 *v* = *c*	.3	0753	*c* 1 *v*	.6	1134	*b* 4 *v* 1 *c*	7.4	1501	*v* 1½ *b*	6.7
0398	*b* 1 *v* 1 *c*	.0	0771	*c* 2 *v* 3 *d*	.7	1153	*v* 1 *b*	6.8	1517	*b* 3 *v* 2 *c*	7.2
0437	*b* 2 *v* 3 *c*	.1	0784	*c* 1½ *v* 4 *d*	.7	1165	*b* 3 *v*	7.2	1537	*b* 3½ *v* 4½ *c*	7.1
0461	*b* 1½ *v* 1½ *c*	.2	0800	*c* 3 *v* 4 *d*	.8	1183	*b* 1 *v*	7.0	1566	*b* 2 *v* 2 *c*	7.2
0482	*b* 2 *v*	.1	0887	*b* 3 *v* 2 *c*	.2	1217	*b* 3 *v* 4 *c*	7.1	1601	*v* = *b*	6.9
0507	*b* 2½ *v* 6 *c*	.1	0901	*c* 1 *v*	.6	1223	*v* = *b*	6.9	1607	*b* 1 *v* 4 *c*	7.0
0538	*b* 1 *v* 2 *c*	.1	1048	*b* 1 *v* 5 *c*	7.0	1255	*v* 1 *c*	7.4	1615	*b* 1½ *v* 2 *c*	7.1
0663	*b* 2 *v* 4 *c*	.1	1067	*v* 2 *b*	6.7	1394	*a* 7 *v* 2 *b*	6.6	1626	*b* 2 *v* 3½ *c*	7.1
0691	*b* 1 *v*	.0	1070	*b* 1 *v*	7.0	1416	*b* 3 *v* 4 *c*	7.1			

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LE MOUVEMENT DE LA COMÈTE WOLF 1884—1911,

By M. KAMENSKY.

Le présent Mémoire contient quelques résultats de mes recherches sur le mouvement de la Comète Wolf durant la période 1884 — 1912, qui comprend 5 retours de la comète vers le Soleil.

Mon article n'est autre que le développement ultérieur de la théorie du mouvement de cette comète; il est la suite des recherches que j'ai déjà publiées en partie dans le journal A. N. 4607. Les données numériques, sur lesquelles s'appuient les conclusions, que je propose à l'attention du lecteur, sont déjà exposées en détail dans les parties IV et V de mes "Recherches sur le mouvement de la Comète Wolf." Ces dernières furent présentées il y a longtemps à l'Académie des Sciences de Russie pour être imprimées dans ses Bulletins. Mais avant que leur tour sous presse ne vint, la révolution russe prit un tel caractère qu'il fut impossible d'accomplir aucun ouvrage scientifique ou de les publier, car les bolchéviques détraisaient et continuent à détraire toute culture ou oeuvre scientifique avec un acharnement qui n'a pas eu son précédent dans l'histoire de l'humanité. Pour cette raison j'ignore ce que sont devenues les IV et V parties de mes "Recherches." Il est probable, qu'elles aient subit le même sort de beaucoup d'autres ouvrages de savants russes qui n'ont pas été publiés.

Il ne parut indispensable d'attentre pour la publication de l'article présent que les IV et V parties de mes "Recherches," sur lesquelles sont basées les résultats proposés, fussent publiées. Mais par suite du retard de la presse et de la difficulté de publier prochainement ces mémoires en détail dans quelques journal que se soit, pour cause de leurs volumes assez importants, je me permets d'exposer ici les principales parties.

Me basant sur le système des éléments I, que j'ai déduit de la liaison préalable des apparitions de la Comète Wolf pendant les années 1884 — 1911, et qui fut publié dans les *A. N.* 4607, j'ai calculé les valeurs précises des perturbations dans le mouvement de cette Comète, produites par la *Terre*, *Mars*, *Jupiter* et *Saturne* pour la période 1884 Sept. 24.0 — 1891 Juillet 10.0. Les perturbations du second ordre avaient déjà été prises en considération. Les résultats que j'ai obtenus se trouvent dans la table ci dessous:

$$\text{I}\quad \begin{aligned} &1884\ \text{Sept. } 24.0\ \text{T. M. Berlin}\\ M &= 352^\circ\ 1'\ 30''.40\\ \varphi &= 34\ \ 7\ 13\ .33\\ \Omega &= 206\ 26\ 58\ .19\\ \pi &= 19\ \ 9\ \ 5\ .54\\ i &= 25\ 15\ 32\ .85\\ n &= 523''.79064 \end{aligned} \quad \left.\begin{matrix}\\ \\ \\ \end{matrix}\right\} 1890.0$$

1884 Sept. 24.0 — 1891 Juillet 10.0

	δ M	δ φ	δ Ω	δ π	δ i	δ n
	′ ″	′ ″	′ ″	′ ″	′ ″	″
La Terre + La Lune	+ 0 39.680	+ 0 0.297	−0 0.902	−0 0.975	+0 0.120	−0.00122
Mars	− 0 2.348	+ 0 0.077	+0 0.034	+0 0.231	−0 0.004	−0.00032
Jupiter	−55 21.069	−15 30.770	−5 20.530	+1 26.096	−1 2.467	−3.66878
Saturne	+ 2 32.457	+ 0 2.751	−0 11.916	−0 55.788	−0 0.248	−0.00264
La Somme	−52 11.280	−15 27.645	−5 33.314	+0 29.564	−1 2.599	−3.67296

En comparant ces valeurs des perturbations à celles qui furent obtenues par M. Thraen et dont je me suis servi dans mes travaux préalables de la liaison des apparitions de la Comète durant 1884 — 1911, j'ai

obtenu les différences suivantes, prises dans le sens: Kamensky — Thraen.

$$
\begin{aligned}
&K - T\\
\Delta M &= +7''.02\\
\Delta \varphi &= +0''.47\\
\Delta \Omega &= +0''.06\\
\Delta \pi &= -0''.02\\
\Delta i &= +0''.14\\
\Delta n &= +0''.00125
\end{aligned}
$$

Par conséquent, ma supposition sur quelque inexactitude des calculs de M. Thraen, exposée déjà en 1912 dans les *A. N.* 4607, se confirme pleinement: Les différences de M et n parurent assez grandes et l'aspect général de la liaison des apparitions de la Comète 1884 — 1911 a changé quelque-peu. D'ailleurs, la part des différences indiquées se produisit par l'emploi par M. Thraen de quelques autres masses planétaires que celles que j'employais toujours.

Les perturbations pour la période suivante, 1891 Juillet 10.0 — 1898 Août 22.0 ont été empruntées de l'ouvrage de M. Thraen: "Bestimmung der Bahn des periodishen Kometen von Wolf," imprimé dans LXIV tom den Denkschriften der Wiener Academie. Ces calculs ont été faits par M. Thraen au moyen d'un assez bon système des éléments. Mais il est regrettable qu'en cela il se soit encore servi d'anciennes masses planétaires, un peu inexactes; vu qu'il n'a publié que *les sommes* des différentielles des perturbations pour les 4 planètes en question, — il était impossible d'etablir la réduction de ses perturbations aux nouvelles masses planetaires. Outre cela, la plus grande partie des calculs de M. Thraen, qui sont conservés dans Königlichen Astronomishen Rechen-Institut zu Berlin, doit être considéré comme perdue. Il est probable, que l'unique moyen de fixer exactement les valeurs des perturbations pour ce laps de temps est de les considérer d'après le nouveau calcul, à moins que ceux de M. Thraen, pour chaque planète en particulier ne soient pas retrouvés à Rechen-Institut. Ces nouvaux calculs sont considérables d'autant plus que j'ai découvert les erreurs dans les différentielles des perturbations de M. Thraen pour 1898.

Cependant on peut considérer que pour la liaison préalable des 5 retours de la Comète vers le *Soleil*, ces erreurs ainsi que certaine différence des masses planétaires sont si insignifiantes qu'il est probable qu'elles ne seront pas en état de changer considérablement l'aspect général des apparitions de la Comète durant 1884 — 1911.

Dans les calculs suivants des perturbations pour la période 1898 Août 22.0 — 1912 Février 11.0, je me suis servi du système des éléments K_1 pour 1898 Août 22.0, déduit par M. Thraen de la liaison préliminaire de deux apparitions de la Comète en 1891 et 1898, et publié par M. Berberich dans les *A. N.* 3940; ces perturbations ont été publiées en détail dans les II et III parties de mes "Recherches."

Enfin, les perturbations pour la période 1912 Février 11.0 — 1918 Décembre 16.0 ont été calculées par moi d'après les systèmes des éléments K'_8 et K'_9, déduits de la liaison des apparitions de la Comète en 1884 — 1911, et imprimés à la fin du Mémoire présent.

Tous les calculs ont été faits par moi d'après la méthode de la variation des constantes arbitraires; les perturbations du second ordre sont toujours prises en considération. Les résultats des calculs ont été vérifiés par différents procédés, exposés en détail dans la partie V de mes "Recherches," et on peut croire qu'ils ne contiennent pas d'erreurs qui puissent influer tant soit peu sur le résultat des liaisons des différentes apparitions de la Comète Wolf.

Par conséquent, toutes les perturbations dans le mouvement de la Comète Wolf, produites par la *Terre*, *Mars*, *Jupiter* et *Saturne* et calculées jusqu'ici, peuvent être rassemblées dans la table ci dessous:

La période	δ M	δ φ	δ Ω	δ π	δ i	δ n	Calculateur
	′ ″	′ ″	′ ″	′ ″	′ ″	″	
1884 Sept. 24 – 1891 Juill. 10	−52 11.28	−15 27.65	−5 33.31	+0 29.56	−1 2.60	−3.67296	Kamensky
1891 Juill. 10 – 1898 Mars. 15	−34 55.58	− 7 43.18	−0 48.09	+3 45.00	−2 14.96	−1.70763	Thraen
1898 Mars. 15 – 1898 Août 22	+ 0 3.40	+ 0 4.31	−0 2.02	−0 22.78	+0 1.11	−0.04276	Thraen
1898 Août 22 – 1904 Juin 12	+38 35.68	+ 4 56.22	−0 3.34	−1 51.59	+2 24.86	+1.68558	Kamensky
1901 Juin 12 – 1906 Mars. 14	+ 2 0.04	+ 0 8.74	−0 25.44	−1 49.91	−0 6.41	+0.25388	Kamensky
1906 Mars. 14 – 1911 Mars. 28	+30 8.54	+ 5 20.74	+0 54.01	+0 51.56	+1 30.33	+1.19376	Kamensky
1911 Mars. 28 – 1912 Févr. 11	+ 0 1.78	+ 0 31.68	−0 2.94	+1 3.84	−0 1.04	−0.01836	Kamensky
1912 Févr. 11 – 1918 Jan. 10	− 0 22.92	+ 3 29.63	−3 7.98	+1 34.52	+1 37.68	+0.94863	Kamensky
1918 Jan. 10 – 1918 Déc. 16	− 0 21.17	− 0 35.27	−0 29.14	+0 57.69	−0 1.52	+0.28900	Kamensky

Le point de départ de tous mes travaux mentionnés ici est le système des éléments K_4 pour 1898 Août 22.0.

1898 Août 22.0 T. M. Berlin

$$K_4.\quad \begin{aligned} M &= 6°\,58'\,10''.03 \\ \varphi &= 33\;44\;\;2\;.97 \\ \Omega &= 206\;29\;\;3\;.03 \\ \pi &= 19\;21\;29\;.55 \\ i &= 25\;12\;15\;.36 \\ n &= 518''.36643 \end{aligned} \left.\begin{matrix} \\ \\ \\ \\ \end{matrix}\right\} 1900.0$$

A l'aide du tableau des perturbations donné plus haut, j'ai formé de ce système K_4 des éléments, des systèmes dérivés $K_1 - K_8$, qui, après les calculs d'égalisation exposés plus loin, sont transformés dans les systèmes $K'_1 - K'_8 - K'_{10}$:

Epoque T. M. B.	Système fondam.	Système amélioré
1884 Sept. 24.0	K_1	K_1'
1891 Juill. 10.0	K_2	K_2'
1898 Mars 15.0	K_3	K_3'
1898 Août 22.0	K_4	K_4'
1904 Juin 12.0	K_5	K_5'
1906 Mars 14.0	K_6	K_6'
1911 Mars 28.0	K_7	K_7'
1912 Févr. 11.0	K_8	K_8'
1918 Janv. 10.0	.	K_9'
1918 Déc. 16.0		K_{10}'

Pour la déduction du système K_4, M. THRAEN fait usage de 2 lieux normaux de la Comète pour 1891, savoir:

1891 Août 9d.5, avec 76 observations
1891 Oct. 3 .5, avec 151 observations

et 9 lieux normaux en 1898 — 1899, embrassant l'intervalle de temps 1898 Juin 16 — 1899 Mars 10, contenant en général 116 observations.

Les systèmes des éléments K_1 — K_7 ont été pris pour base des calculs de la liasion préliminaire des 5 retours de la Comète vers le *Soleil* durant la periode 1884 — 1911. Je me suis servi pour ce travail des positions normales suivantes de la Comète:

No.	T. M. Berlin	α	δ	Nombre d'obs.	Equin.
	d	° ′ ″	° ′ ″		
1	1884 Sept. 27.5	319 50 17.36	+19 11 49.37	185	1884.0
2	1884 Nov. 12.5	338 51 21.06	− 0 46 23.93	203	1884.0
3	1891 Sept. 6.5	56 12 40.50	+23 31 38.39	174	1891.0
4	1891 Nov. 3.5	70 5 15.23	− 3 36 58.25	87	1891.0
5	1898 Juill. 18.5	57 23 26.93	+19 36 36.20	22	1898.0
6	1898 Sept. 17.5	94 17 42.79	+ 7 49 22.40	43	1898.0
7	1911 Juill. 20.0	274 44 56.27	+15 11 59.84	10	1911.0
8	1911 Août 14.0	270 48 10.32	+13 6 10.74	9	1911.0

J'ai pensé pouvoir prendre, pour cette liaison preliminaire, seulement les 2 lieux normaux, de poids maximum, à chaque apparition de la Comète. Il me parut peut raissonnable de prendre en ce moment le nombre supérieur des lieux normaux. J'ai fait ceci non seulement pour les raisons mentionnées plus haut, concernant l'inexactitude soupçonnée dans les perturbations pour la période 1891 — 1898, mais par suite de ce que les perturbations dans le mouvement de la Comète, causées par *Venus* pendant la période 1884 — 1911 — 1918, n'ont pas été du tout prises en considération. Quoi que ces dernières, vu la distance périhélie de la Comète (q = 1.60) ne peuvent avoir une grande importance, d'autant plus, qu'elles ne sont pas encore déterminées, — faire la liaison de tous les lieux normaux de la Comète, sera un travail peu raisonnable et ne donnera pas l'utilité qu'on pourrait attendre d'une telle besogne.

Et ce n'est qu'après la résolution de ces deux questions qu'il sera possible d'entreprendre les travaux sur l'invention des systèmes des éléments les plus probables, satisfaisant toutes les positions normales de la Comète, pendant ses 6 retours vers le *Soleil*, savoir:

1884 — 1885, 1891 — 1892, 1898 — 1899, (1904 — 1905), 1911 — 1912, 1918 — 1919.

M. THRAEN agit d'une manière semblable pendant ses travaux sur la liaison des apparitions de la Comète en 1884 — 1885 et en 1891 — 1892, quand il crut possible de se servir des 12 positions normales de la seconde apparition, et seulement des 4 positions normales de la première apparition, en retranchant les dernières 4 (Denkschriften d. Wiener Academie, Band LXIV).

Les lieux normaux de la Comète pour 1884 et 1891 sont empruntés à l'ouvrage mentionné de M. THRAEN. Les lieux normaux pour 1898 sont tirés des manuscrits de M. THRAEN, après les avoir vérifiés par mes calculs. Quant à ce qui concerne les positions normales pour 1911, elles ont été formées par moi, aprés une scrupuleuse élaboration des observations de la Comète en 1911.

Les perturbations planétaires des époques, pour lesquelles ont été déduits les systèmes K_1, jusqu'aux moments, correspondant aux lieux normaux, sont données dans la table suivante:

	δ M	$\delta\varphi$	$\delta\Omega$	$\delta\pi$	δ i	δ n
1884 Sept. 24.0 — Sept. 27.5	− 0.14	− 0.26	−0.14	+ 0.14	+0.07	+0.0020
1884 Sept. 24.0 — Nov. 12.5	− 0.77	− 4.64	−1.15	+ 2.07	+0.99	+0.0339
1891 Juill. 10.0 — Sept. 6.5	+ 1.47	−16.14	−4.31	− 7.24	+3.83	+0.1094
1891 Juill. 10.0 — Nov. 3.5	+15.89	−33.03	−3.49	− 8.25	+5.61	+0.2288
1898 Mars 15.0 — Juill. 18.5	+ 3.91	+ 6.72	−1.95	−19.88	+1.14	−0.0610
1898 Août 22.0 — Sept. 17.5	+ 2.01	− 1.92	−0.09	− 3.24	−0.07	+0.0157
1911 Mars 28.0 — Juill. 20.0	−14.14	+12.74	−3.34	+49.79	−0.64	+0.0686
1911 Mars 28.0 — Août 14.0	−13.34	+14.76	−3.58	+56.26	−0.66	+0.0721

En les prenant en considération, j'ai obtenu les positions suivantes calculées de la Comète, c'est à dire basées sur les systèmes K_1 — K_7, corrigés par les perturbations:

No	T. M. Berlin	α	δ	Equin.
1	1884 Sept. 27.5	319 50 7.16	+19 11 45.55	1884.0
2	1884 Nov. 12.5	338 51 14.77	− 0 46 25.13	1884.0
3	1891 Sept. 6.5	56 12 40.79	+23 31 38.47	1891.0
4	1891 Nov. 3.5	70 5 13.91	− 3 36 57.30	1891.0
5	1898 Juill. 18.5	57 23 27.59	+19 36 37.02	1898.0
6	1898 Sept. 17.5	94 17 42.60	+ 7 49 22.36	1898.0
7	1911 Juill. 20.0	274 45 28.05	+15 12 13.50	1911.0
8	1911 Août 14.0	270 48 36.76	+13 6 26.80	1911.0

En les comparant avec les positions normales, données plus haut, j'ai obtenu les écarts suivants des systèmes K_1 des observations:

No	T. M. Berlin	$\Delta\alpha''\cos\delta$	$\Delta\delta''$
1	1884 Sept. 27.5	+ 9.63	+ 3.82
2	Nov. 12.5	+ 6.29	+ 1.20
3	1891 Sept. 6.5	− 0.27	− 0.08
4	Nov. 3.5	+ 1.32	− 0.95
5	1898 Juill. 18.5	− 0.62	− 0.82
6	Sept. 17.5	+ 0.19	+ 0.04
7	1911 Juill. 20.0	−30.67	−13.66
8	Août 14.0	−25.74	−16.06

De cette manière j'ai formé, d'après les règles bien connues, les équations de condition ci-dessous. Dans ces équations les coefficients sont exprimés en logarithmes, et l'origine du temps est 1884 Sept. 24.0 T. M. B.

	$d\pi$	dn	$d\Omega$	di	$d\varphi$	dM	
1884 Sept. 27.5	0.2657	+2.3184n	+9.4241n	+9.2169n	+0.6222n	+0.8107	= + 9.63
Nov. 12.5	0.1384	1.6251	9.2680n	8.3736n	0.3025n	0.7645	= + 6.29
1891 Sept. 6.5	0.0979	4.1333	8.2347n	8.3513	0.2766	0.7207	= − 0.27
Nov. 3.5	0.3006	4.2543	8.7122n	9.2476n	0.6351	0.8360	= + 1.32
1898 Juill. 18.5	9.8181	4.1612	8.9871n	7.4571n	0.0455	0.4548	= − 0.62
Sept. 17.5	9.9439	4.1073	8.0672n	9.0785n	0.3950	0.3937	= + 0.19
1911 Juill. 20.0	0.1589	4.3200	9.0614n	9.4468n	0.5303n	0.3302	= −30.67
Août 14.0	0.1134	4.2775	9.0616n	9.4270n	0.5040n	0.2882	= −25.74

1884 Sept. 27.5	9.6097$d\pi$	+1.8513dn	+9.8013d☊	+0.0936di	+9.3951$n d\varphi$	+0.2455dM	=	+ 3.82
Nov. 12.5	8.8544n	2.0131n	9.8402	9.4785	9.7828n	9.5261n	=	+ 1.20
1891 Sept. 6.5	9.6651n	3.6934n	9.8331	9.1446	9.5870	0.2942n	=	− 0.08
Nov. 3.5	9.4239n	3.2586n	9.9043	9.9940n	0.0032n	9.8190n	=	− 0.95
1898 Juill. 18.5	9.3144n	3.6466n	9.5591	8.2521n	8.9361	9.9462n	=	− 0.82
Sept. 17.5	9.4075n	3.6578n	9.5942	9.7871n	9.6897n	9.9498n	=	+ 0.04
1911 Juill. 20.0	9.5189	3.9262	9.1585n	0.1416	9.9957n	9.9307	=	−13.66
Août 14.0	9.5482	3.9371	8.8948n	0.1244	9.9288n	9.9420	=	−16.06

La somme des carrés des écarts est

$$(nn) = 2199.84$$

L'erreur moyenne d'un lieu normal $\epsilon = \pm 14''.83$
L'erreur probable d'un leiu normal $\rho = \pm\ 9\ .89$

En posant

$x = d\pi$ $\quad t = di$
$y = 10^4.dn$ $\quad u = d\varphi$
$z = d☊$ $\quad w = dM$

et en donnant des poids égaux à toutes les équations de condition, en nous basant sur les remarques, faites plus haut, du caractère de cette liaison préalable, et suivant dans cette circonstance l'example de M. Backlund qui est une autorité bien connue dans les quetions du mouvement des Comètes (Voyez: La Comète d'Encke 1891—1908, Fascicule III, pg. 30), j'ai obtenu les équations normales suivantes:

1.22228x	+1.14459y	+0.24895nz	+9.39967t	+0.77735nu	+1.72278w	=	1.75946n
1.14459	1.27660	0.20817n	0.07591	9.91751	1.58179	=	2.13519n
0.24895n	0.20817n	0.38614	9.12385n	9.92737	0.74989n	=	0.90854
9.39967	0.07591	9.12385n	0.83935	9.11059	0.21617	=	1.31871n
0.77735n	9.91751	9.92737	9.11059	1.88129	0.67879n	=	2.20931
1.72278	1.58179	0.74289n	0.21617	0.67879n	2.26344	=	1.45179n

De là les équations d'éliminations:

1.22228x	+1.14459y	+0.24895nz	+9.39967t	+0.77735nu	+1.72278 w	=	1.75946n
	0.85977y	+9.11921nz	+9.99172t	+0.76604 u	+0.77744nw	=	1.94676n
		0.35063 z	+8.91685nt	+9.49862 u	+9.05901nw	=	9.57864
			0.83044 t	+9.74750nu	+0.21947 w	=	0.90113n
				1.83973 u	+1.28258 w	=	2.32610
					0.74184 w	=	1.37457

La solution de ces équations conduit aux corrections suivantes du système des éléments K_1:

$\Delta M = +4''.29$ $\quad \Delta\pi = -8''.05$
$\Delta\varphi = +1''.87$ $\quad \Delta i = -2''.07$
$\Delta☊ = +0''.04$ $\quad \Delta n = -0''.00099$

De cette manière j'ai trouvé les systèmes améliorés des éléments de la Comète:

Système	K_1'	K_2'	K_3'	K_4'	K_5'
Epoque et oscul.	1884 Sept. 24.0	1891 Juill. 10.0	1898 Mars 15.0	1898 Août 22.0	1904 Juin 12.0
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
M	352 1 28.62	351 59 13.53	343 55 40.58	6 58 9.29	312 52 19.69
φ	34 7 11.36	33 51 43.71	33 44 0.53	33 44 4.84	33 49 1.06
☊	206 18 30.55	206 21 25.14	206 29 5.09	206 29 3.07	206 28 59.73
π	19 0 45.85	19 9 37.37	19 21 44.28	19 21 21.50	19 19 29.91
i	25 15 37.71	25 14 31.14	25 12 12.18	25 12 13.29	25 14 38.15
n	523″.78879	520″.11583	518″.40820	518″.36544	520″.05102
Equin.	1880.0	1890.0	1900.0	1900.0	1900.0

Système	K_6'	K_7'	K_8'	K_9'	K_{10}'
Epoque et oscul.	1906 Mars 14.0	1911 Mars 28.0	1912 Févr. 11.0	1918 Jan. 10.0	1918 Déc. 16.0
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
M	45 21 32.40	311 47 41.95	358 9 3.30	311 1 57.83	0 22 2.50
φ	33 49 9.80	33 54 30.54	33 55 2.22	33 58 31.85	33 57 56.58
☊	206 37 2.25	206 37 56.26	206 37 53.32	206 43 13.30	206 42 44.16
π	19 26 2.00	19 26 53.56	19 27 57.40	19 37 53.95	19 38 51.64
i	25 14 27.77	25 15 58.10	25 15 57.06	25 17 30.77	25 17 29.25
n	520″.30490	521″.49866	521″.48030	522″.42893	522″.71793
Equin.	1910.0	1910.0	1910.0	1920.0	1920.0

Ces systèmes représentent les lieux normaux de la Comète comme il suit:

Epoque	Calcul direct		Par les diff. coeff.	
T. M. B.	$\Delta\alpha'' \cos\delta$	$\Delta\delta''$	$\Delta\alpha'' \cos\delta$	$\Delta\delta''$
d	″	″	″	″
1884 Sept. 27.5	+3.96	+2.74	+4.03	+2.63
Nov. 12.5	−3.90	+3.65	−3.83	+3.69
1891 Sept. 6.5	−2.90	−0.69	−2.79	−0.72
Nov. 3.5	−2.30	−2.25	−2.70	−2.23
1898 Juill. 18.5	+4.65	−3.12	+5.08	−3.29
Sept. 17.5	+4.50	−3.06	+4.40	−3.06
1911 Juill. 20.0	−1.67	−2.16	−1.80	−1.92
Août 14.0	+0.46	−4.13	+0.57	−4.06

En plus:

$$[vv] = +161.09$$
$$[nn] = +160.60$$

d'ou le lieu normal de la Comète sera présenté avec les erreurs:

moyenne $\epsilon = \pm 4''.01$
probable $\rho = \pm 2\ .67$

Je considère les systemes $K'_1 - K'_{10}$ comme fondamentals dans toutes mes recherches ultérieures du mouvement de la Comète.

En prenant en considération tous les détails, mentionnés plus haut, nous devons considérer nos resultats, obtenus de la liaison, suffissamment satisfaisants.

Il est remarquable, que le caractère et la répartition des résidus obtenus est assez près de celui que j'ai obtenu à la première liaison preliminaire, produite avec des valeurs pas tout à fait exactes des perturbations pour la période 1884 — 1891 (Voyez *A. N.* 4607, pg. 417 — 418).

Je m'abstiens de faire des déductions des résultats que j'ai obtenus, d'autant plus que j'ai l'espoir de publier prochainement, s'il plait à Dieu, mes calculs postérieurs, concernant la représentation par les systèmes $K'_9 - K'_{11}$ des observations de la Comète en 1918, et les résultats de la liaison de 6 retours de la Comète vers le *Soleil* pendant 1884 — 1918.

Vladivostock, Decembre, 1918.

STELLAR PARALLAXES DERIVED FROM PHOTOGRAPHS MADE WITH THE 60-INCH REFLECTOR OF THE MOUNT WILSON OBSERVATORY.

By A. van Maanen.

The following table, giving a summary of the results obtained from the Mount Wilson parallax work, is a continuation of the list published in *Astronomical Journal*, No. 723. The full details for the individual objects are to be found in "The Photographic Determination of Stellar Parallaxes with the 60-Inch Reflector," third series (Mount Wilson Contributions, No. 158), and fourth series (in press).

The table is self-explanatory. The magnitudes are taken from the *Revised Harvard Photometry*, except when stated otherwise in the foot-notes. The spectra have been determined by Mr. Adams, except those marked by an asterisk, which are from the *Revised Harvard Photometry*. The proper-motions are from Boss's *Preliminary General Catalogue*, except when otherwise stated in the foot-notes and for *W. B.* 4^h 1189, for which Porter's proper-motion is given. The values in the eighth column are relative parallaxes; to convert them into absolute parallaxes about 0″.002 should be added. The mean probable error of a parallax is 0″.0055; the mean number of exposures is 16, and of comparison stars 8.

Object	α 1900	δ 1900	No. *B. D.*	Mg.	Sp.	μ	π	P. E.	No. Exp.	No Comp Stars
	h m s	°	°			"	"	"		
N. G. C. 224	0 37 17	+40 43	+40 148	. . .	Sp. Neb.		+0.004	0.005	16	9
P. G. C. 161	0 41 19	+14 56	+14 111	5.58	Mb (G_8)	0.064	+0.012	0.005	16	8
Anonymous (1)	0 43 52	+ 4 55	. . .	12.34	F_0	3.01	+0.244	0.008	16	7
P. G. C. 217	0 54 39	+ 5 57	+ 5 131	6.31	Mb (G_6)	0.023	−0.003	0.007	18	6
340	1 28 30	+36 43	+36 277	5.77	B_9	0.025	+0.015	0.007	18	8
373	1 35 44	+25 14	+25 276	6.26	F2p	0.135	+0.034	0.004	16	8
582	2 29 43	+34 15	+34 469	5.62	Ma (G_7)	0.062	+0.013	0.005	16	10
Anonymous (2)	2 45 44	+22 38	. .	12.1	. . . . .		−0.003	0.009	16	14
Anonymous (3)	2 45 54	+22 37	. .	10.4	. . . . .	. .	+0.011	0.009	16	14
P. G. C. 660	2 50 11	+17 56	+17 457	5.94	Mc (G_8)	0.018	+0.009	0.006	16	7
712	3 2 41	+18 25	+18 414	6.48	K_6	0.042	+0.029	0.005	16	10
Nova Persei (4)	3 24 24	+43 34	. . . .	13.0	O		+0.007	0.004	14	9
889	3 46 24	+48 21	+48 1015	5.92	G_9	0.058	+0.018	0.002	16	11
1154	4 48 10	+ 2 21	+ 2 800	5.67	Ma*	0.031	+0.007	0.002	14	8
1182	4 53 26	+39 15	+39 1133	6.00	F_0	0.013	0.000	0.003	18	8
W. B. 4h 1189	4 55 51	− 5 52	− 5 1123	6.50	K_4	1.250	+0.107	0.006	20	8
P. G. C. 1256	5 11 7	+42 41	+42 1239	5.88	Mb*	0.049	+0.005	0.004	16	9
1267	5 13 20	+20 2	+19 893	6.22	K_0	0.048	+0.019	0.005	18	10
1629	6 22 8	+30 33	+30 1238	var.	F8p	0.024	+0.006	0.004	14	9
1643	6 24 57	+78 5	+78 227	5.88	K_4	0.019	+0.015	0.005	20	7
1822	6 59 36	+34 38	+34 1524	5.60	G_4	0.087	+0.034	0.004	16	8
1846	7 5 36	+51 36	+51 1295	5.69	Mb (G_9)	0.019	+0.008	0.003	16	8
N. G. C. 2392 (5)	7 23 15	+21 7	+21 1609	10.0	Plan. Neb.	. . .	+0.020	0.003	18	8
P. G. C. 2245	8 21 12	+12 59	+13 1912	5.75	Mb (G_4)	0.116	+0.027	0.005	16	10
2378	8 46 28	+28 38	+28 1659	6.31	Mb (G_7)	0.022	−0.001	0.009	16	6
2442_1	9 1 41	+23 23	+23 2048	7.26	F_3	0.161	+0.018	0.007	14	7
2442_2	9 1 41	+23 23		7.74	F_1		+0.016	0.006	16	7
2660	9 50 15	+57 54	+58 1224	5.99	G_4	0.068	+0.004	0.006	16	8
2663	9 51 8	+ 9 24	+ 9 2262	5.93	K_1	0.090	+0.008	0.007	16	9
2800	10 26 52	+14 39	+14 2255	5.74	Ma*	0.041	+0.003	0.003	14	7
2915	10 50 50	+ 6 43	+ 6 2369	6.05	Mc (G_5)	0.023	−0.006	0.005	16	8
3030	11 25 16	+18 58	+19 2459	5.74	K_0	0.078	+0.022	0.007	14	6
3141	11 56 32	+36 36	+36 2230	5.62	G_9	0.136	+0.034	0.006	14	6
3169	12 4 34	+ 2 28	+ 2 2517	6.13	K_2	0.189	+0.026	0.005	18	5
N. G. C. 5194	13 25 40	+47 43	+47 2063	. . . .	Sp. Neb.	. . .	+0.005	0.008	16	8
P. G. C. 3581	13 46 44	+35 10	+35 2493	6.00	Ma*	0.072	+0.010	0.004	16	7
3658	14 10 22	+41 59	+42 2472	6.22	K_3	0.122	+0.023	0.005	16	7
3983	15 34 59	+80 47	+80 480	6.93	G_3	0.246	+0.010	0.016	16	7
3986	15 35 12	+80 47	+80 481	7.61	. . . .	0.230	+0.031	0.016	16	7
4195	16 23 28	+ 0 53	+ 0 3529	5.47	K_5	0.076	+0.014	0.007	16	11
4343	16 59 55	+35 33	+35 2911	6.75	Mb (G_7)	0.058	+0.007	0.005	20	8
Anonymous (6)	17 52 54	+ 4 28	. . . .	9.67	Mb	10.296	+0.519	0.006	18	8
N. G. C. 6720 (5)	18 49 53	+32 54	. . . .	14.7	Plan. Neb.	. . . .	+0.002	0.005	14	9
P. G. C. 4817	18 53 48	+17 14	+17 3799	5.37	F_8	0.009	−0.001	0.004	16	8
N. G. C. 6804 (5)	19 26 48	+ 9 1	. . . .	13.4	Plan. Neb.	. . . .	+0.020	0.003	18	8
P. G. C. 5083	19 48 58	+46 46	+46 2793	5.51	B_2	0.015	+0.007	0.005	16	10
B. D. +36° 3956 (7)	20 10 47	+36 21	+36 3956	8.0	O	. . . .	−0.005	0.006	20	9
N. G. C. 6905 (5)	20 17 56	+19 47	. . . .	14.5	Plan. Neb.	. . . .	+0.013	0.002	18	9
P. G. C. 5469	20 55 53	+18 56	+18 4675	5.96	Ma*	0.075	+0.007	0.004	16	7

Object	α 1900	δ 1900	No. *B. D.*	Mg.	Sp.	μ	π	P. E.	No. Exp.	No. Comp. Stars
	h m s	° ′	°			″	″	″		
N. G. C. 7008 (5)	20 57 38	+54 10	. . . .	12.8	Plan. Neb.		+0.014	0.004	20	9
P. G. C. 5602	21 41 51	+25 6	+24 4473	6.48	K_1	0.148	+0.003	0.005	14	8
6129	23 47 32	+74 59	+74 1047	6.55	K4p	0.332	+0.097	0.004	18	7

FOOT-NOTES

(1) This star was found by VAN MAANEN to have a proper-motion of 3″.91 annually; the magnitude as determined by SEARES is 12.34 photovisual, 12.91 photographic.

(2) The magnitude is that published by BURNHAM in *Measures of Proper-Motion Stars.* BURNHAM suspected a large proper-motion, which, however, was not confirmed by later observations.

(3) The magnitude is that published by PUISEUX in *Bulletin Astronomique*, *26*, 416, 1909. PUISEUX suspected the star to have a large proper-motion, but later observations have shown that it has no considerable motion.

(4) The magnitude was derived from the parallax plates and is on the scale of *Lick Observatory Bulletin*, No. 8.

(5) To derive a homogeneous system for the photographic magnitudes of the central stars of the planetary nebulæ, counts were made of the number of stars of equal and brighter magnitudes in as large an area as the plates allowed; then with the help of Table IV of *Groningen Publications*, No. 27, the apparent photographic magnitudes were determined.

(6) This star was found by BARNARD to have a proper-motion of 10″.3 annually; the magnitude as determined by SEARES is 9.67 photovisual, 11.43 photographic.

(7) The magnitude is that given in the *Bonner Durchmusterung*.

1919 EPHEMERIS OF (886) *WASHINGTONIA*.

BY ERNEST CLARE BOWER.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

The following ephemeris is derived from elements in *A. J. 31*, 155. Magnitude at opposition is 14.1.

G. C. T.	α_{1900}		δ_{1900}		(log r) log ρ
1919	h m		° ′		
Jan. 1	9 35.7		+35 16		(0.547)
		6.0		72	
11	9 29.7		36 28		0.426
		8.0		66	
21	9 21.7		37 34		0.423
		9.2		54	
31	9 12.5		38 28		0.424
		9.5		37	
Feb. 10	9 3.0		39 5		0.430
		8.9		17	
20	8 54.1		39 22	—	0.440
		7.5		1	
Mar. 2	8 46.6		39 21		0.455
		5.6		17	
12	8 41.0		39 4		0.471
		3.2		31	
22	8 37.8		38 33		0.490
		0.9		40	
Apr. 1	8 36.9		+37 53		(0.569)

U. S. Naval Observatory,
Washington, D. C.,
1919 June 18.

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OBSERVATIONS OF COMETS,

MADE WITH THE 40-INCH AND 12-INCH REFRACTORS OF THE YERKES OBSERVATORY.

By GEORGE VAN BIESBROECK.

Date	Gr. M.T.	Δα	Δδ	No. of Comp.	App. α	App. δ	log pΔ		*	Instr.
			Comet Wolf 1916 *b*							
1917	h m s	m s	″		h m s	° ′ ″				″
July 8	19 41 27	+0 19.92	− 2 27.0	6, 6	23 0 48.97	+21 40 21.9	9.398*n*	0.488	1	12
10	18 52 54	−0 3.07	− 2 5.3	6, 6	3 50.46	24 38 26.2	9.529*n*	0.541	2	40
19	19 44 4	+0 13.69	+ 4 21.0	6, 6	16 15.96	24 5 56.8	9.287*n*	0.475	3	40
23	16 52 5	+0 3.80	+ 4 25.2	6, 6	20 49.36	23 39 29.6	9.629*n*	0.633	4	12
24	18 31 7	−0 3.11	+ 4 13.0	6, 6	21 59.34	23 30 51.0	9.472*n*	0.533	5	40
27	17 21 48	−0 27.86	+ 4 22.2	6, 6	25 1.18	23 3 54.3	9.581*n*	0.597	6	12
Aug. 7	18 23 21	−1 0.40	− 0 49.1	8, 4	33 49.66	20 42 35.0	9.364*n*	0.550	7	40
14	20 33 15	+0 14.80	− 3 35.3	6, 6	37 23.70	18 38 42.7	8.834	0.551	8	12
16	16 43 35	+0 19.71	+ 2 18.1	4, 6	38 5.19	18 2 42.2	9.524*n*	0.630	9	40
18	20 40 51	+0 20.18	+ 1 26.3	6, 6	38 45.20	17 18 11.4	9.032	0.577	10	12
24	19 48 15	+0 0.62	+ 3 13.2	6, 6	39 59.78	15 6 5.5	8.706	0.606	11	12
Sept. 10	20 20 18	−0 23.09	− 3 6.0	6, 6	39 58.15	8 0 3.1	9.089	0.701	12	12
15	18 17 25	−0 0.80	− 6 40.2	6, 6	39 28.39	5 54 42.4	8.625	0.718	13	40
17	19 16 16	+3 29.88	− 7 27.0	25, 5	23 39 15.17	+ 5 3 36.3	9.218	0.730	14	12
			Comet Encke 1917 *c*							
1918										
Mar. 1	13 26 52	−0 36.49	. . . .	6	0 34 37.42	. . . . . .	9.641	. . .	15	12
1	13 26 52	. . . . . .	− 1 24.0	6	. . . .	+10 58 29.5	. . . .	0.754	16	12
2	13 28 46	+1 31.85	+ 2 26.9	6, 6	0 36 56.57	+11 7 26.0	9.642	0.755	17	12
			Wolf's Periodic Comet 1918 *b*							
1918										
July 11	18 45 10	+0 13.26	− 0 4.1	6, 6	20 34 7.49	+24 58 23.0	8.729*n*	0.422	18	40
13	20 34 55	+0 0.76	− 2 0.4	6, 6	33 2.37	25 17 13.8	9.277	0.449	19	40
18	20 21 12	+0 10.21	+ 1 55.8	6, 6	30 4.58	25 56 7.2	9.317	0.442	20	40
20	18 52 34	+0 12.27	− 0 9.0	6, 6	28 48.35	26 8 36.1	8.674	0.393	21	40
27	16 38 11	−0 5.44	+ 2 7.7	6, 6	23 50.68	26 39 50.8	9.218*n*	0.407	22	40
30	18 20 8	+0 7.24	− 5 1.9	6, 6	21 28.19	26 46 14.5	8.888	0.381	23	40
Aug. 3	16 24 30	+0 6.59	− 0 26.1	6, 6	18 22.28	26 47 35.6	9.101	0.391	24	40
4	19 4 26	+0 4.69	− 4 0.7	6, 6	17 29.07	26 46 32.6	9.330	0.426	25	40
7	21 28 59	+0 0.09	− 0 30.1	6, 6	15 1.62	26 40 3.5	9.646	0.614	26	40
18	18 26 52	−0 10.00	− 1 23.3	6, 6	7 9.01	25 36 20.9	9.419	0.476	27	40
31	16 53 46	+0 2.73	+ 1 41.0	6, 6	20 1 6.77	+23 1 33.6	9.284	0.496	28	40

Date	Gr. M.T.	Δα	Δδ	No. of Comp.	App. α	App. δ	log pΔ		*	Instr.
				Wolf's Periodic Comet 1918 *b* (*Continued*)						
1918	h m s	m s	′ ″		h m s	° ′ ″				″
Sept. 11	15 33 16	−0 58.11	− 2 16.2	12 , 6	20 0 30.47	+19 56 16.7	9.075	0.535	29	40
28	13 27 30	−0 7.34	+ 3 20.1	8 , 8	9 33.29	14 13 30.9	8.150*n*	0.618	30	40
29	13 55 35	+0 1.00	− 2 11.3	6 , 6	10 29.70	13 51 52.6	8.648	0.624	31	40
Oct. 3	15 45 34	−1 44.34	− 0 43.6	8 , 4	14 42.29	12 25 12.4	9.418	0.668	32	40
6	13 57 32	−0 14.56	− 2 48.2	6 , 6	20 18 9.73	+11 23 24.1	8.932	0.658	33	40
Nov. 23	12 18 5	+0 11.18	+ 5 21.1	6 , 6	21 55 23.43	− 1 40 37.4	8.842	0.786	34	12
26	14 51 26	−0 11.63	− 2 13.4	6 , 6	22 3 31.71	− 2 8 38.8	9.512	0.784	35	12
30	14 3 37	+0 3.10	− 3 5.9	6 , 6	22 14 6.50	− 2 40 3.5	9.425	0.789	36	12
1919 Jan. 3	12 33 54	+1 20.68	− 1 46.6	10 , 5	23 48 44.66	− 3 59 15.8	9.268	0.809	37	12
24	12 48 49	+0 6.90	+ 1 3.6	6 , 6	0 47 13.80	− 2 41 10.1	9.397	0.790	38	12
25	12 34 43	+0 10.90	− 4 33.4	6 , 6	0 49 56.61	− 2 35 55.1	9.158	0.792	39	12
31	12 46 4	+0 20.70	− 0 45.2	6 , 6	1 6 19.66	− 2 2 20.5	9.411	0.786	40	12
Feb. 1	12 44 8	+0 9.36	− 2 5.5	6 , 6	1 9 2.19	− 1 56 29.5	9.410	0.785	41	12
Mar. 21	13 49 43	−0 2.91	−10 47.2	6 , 6	3 13 29.14	+ 3 12 23.1	9.607	0.762	42	12
				Borrelly's Periodic Comet 1918 *c*						
1918 Aug. 31	21 23 42	−0 0.97	− 3 10.2	6 , 6	4 34 19.15	−14 1 50.0	9.423*n*	0.846	43	40
Sept. 5	21 58 25	−2 35.85	+ 2 46.6	8 , 4	4 45 18.81	−13 29 47.4	9.284*n*	0.853	44	40
8	21 31 57	−0 8.98	+ 1 30.1	6 , 6	4 51 45.74	−13 9 21.5	9.359*n*	0.847	45	40
15	21 21 23	. . . .	+ 0 38.6	3	. . . . .	−12 15 28.0	. . . .	0.846	46	40
15	21 35 6	−2 31.86	. . . . .	6	5 6 40.01	. . . .	9.344*n*	. .	46	40
28	20 26 33	+0 1.65	+ 0 49.4	8 , 8	5 33 11.50	−10 6 37.1	9.432*n*	0.828	47	40
Oct. 6	20 0 59	−0 11.84	+ 0 53.3	6 , 6	5 48 40.05	− 8 19 42.1	9.449*n*	0.818	48	40
12	20 42 30	−0 30.51	+ 0 22.6	12 , 6	5 59 48.70	− 6 39 17.3	9.293*n*	0.816	49	40
13	21 39 53	−0 10.99	+ 0 11.4	6 , 6	6 1 41.17	− 6 19 54.8	8.952*n*	0.819	50	40
Nov. 10	17 37 26	−0 9.05	+ 6 23.9	6 , 6	6 44 18.29	+ 7 54 39.7	9.557*n*	0.729	51	40
24	17 24 15	−1 39.10	+ 1 2.7	10 , 4	6 57 41.07	+20 42 22.6	9.540*n*	0.604	52	40
26	15 42 57	+0 1.50	+ 0 29.1	6 , 6	6 58 54.81	+22 46 8.1	9.650*n*	0.672	53	12
Dec. 3	16 32 23	−0 16.42	+ 0 49.5	6 , 6	7 1 48.85	30 40 38.7	9.608*n*	0.496	54	40
1919 Jan. 2	17 22 4	−0 22.44	+ 1 4.3	6 , 6	6 44 36.23	58 49 27.1	9.031*n*	0.388*n*	55	12
3	17 30 51	−1 11.43	− 1 24.2	10 , 6	6 43 26.25	59 22 36.7	8.755*n*	0.408*n*	56	40
8	17 29 29	−0 15.41	+ 2 42.3	6 , 6	6 37 41.	61 46.4 . .	8.515	0.465*n*	57	40
10	16 55 22	+0 1.58	− 4 1.0	6 , 6	6 35 42.91	62 30 43.9	8.814*n*	0.479*n*	58	40
13	16 41 57	+0 6.86	− 1 46.5	6 , 6	6 32 52.09	63 30 22.0	8.795*n*	0.499*n*	59	40
15	16 28 24	+0 6.77	+ 2 11.7	6 , 6	6 31 13.03	64 3 51.6	8.968*n*	0.509*n*	60	40
16	15 57 13	−0 9.85	+ 0 52.7	6 , 6	6 30 30.03	64 18 40.6	9.293*n*	0.501*n*	61	40
17	16 34 22	+0 31.91	+ 0 54.0	8 , 8	6 29 47.76	64 33 3.4	8.186*n*	0.521*n*	62	40
18	14 15 19	+1 3.56	− 1 8.1	6 , 6	6 29 15.68	64 44 41.0	9.769*n*	0.362*n*	63	12
19	17 37 28	+0 30.73	+ 0 40.6	6 , 6	6 28 36.37	64 58 20.4	9.481	0.381*n*	64	40
20	14 51 32	+0 35.45	− 1 44.9	6 , 6	6 28 12.08	65 8 0.6	9.596*n*	0.469*n*	65	12
24	13 58 17	−0 5.50	− 3 12.0	6 , 6	6 27 2.54	65 42 18.6	9.751*n*	0.408*n*	66	12
31	13 11 16	+0 29.40	− 3 26.8	6 , 6	6 28 3.19	66 12 43.2	9.815*n*	0.365*n*	67	12
Feb. 1	13 2 19	−0 52.34	− 3 57.0	6 , 6	6 28 30.78	66 14 24.6	9.829*n*	0.349*n*	68	12
5	13 47 30	−0 9.81	+ 1 29.4	6 , 6	6 31 12.06	66 15 27.1	9.646*n*	0.481*n*	69	12
23	16 58 49	−0 51.87	− 2 19.7	6 , 6	6 56 21.61	64 53 24.3	9.768	0.361*n*	70	40
Mar. 2	16 31 1	−0 32.85	+ 5 17.5	6 , 6	7 9 52.45	+63 54 1.7	9.713	0.372*n*	71	40

Comparison Stars.

Mean Co-ordinates for Beginning of Year and Reductions to Apparent Places

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	23 0 25.82	+24 42 37.8	+3.23	+11.1	Paris ph. +24°, 22h 56m No. 141; Oxf. ph. 25° 80494.
2	3 50.25	24 40 19.8	3.28	11.7	Paris ph. +24°, 23h 4m No. 53; Oxf. ph. 25° 80485.
3	15 58.78	24 1 21.6	3.49	14.2	Paris ph. +24°, 23h 12m No. 340; +23°, 23h 16m No. 70.
4	20 41.97	23 34 49.1	3.59	15.3	Paris ph. +24°, 23h 20m No. 211; +23°, 23h 16m No. 156.
5	21 58.84	23 26 22.4	3.61	15.6	Paris ph. +24°, 23h 20m No. 223; +23°, 23h 24m No. 27.
6	25 25.36	22 59 15.5	3.68	16.6	Kü 10404.
7	34 46.14	20 43 4.3	3.92	19.8	Paris ph. +21° 23h 32m No. 180.
8	37 4.85	18 41 56.2	4.05	21.8	*A.G. Berl. A* 9661.
9	37 41.39	18 0 1.7	4.09	22.4	*A.G. Berl. A* 9663.
10	38 20.90	17 16 22.1	4.12	23.0	Bordeaux Obs. mer. *B.D.* 16° 1968.
11	39 54.94	15 2 27.7	4.22	24.6	Bord. ph. +14°, 23h 36m No. 79; 15°, 23h 40m No. 113; 16°, 23h 36m No. 235
12	40 16.82	8 2 11.0	4.42	28.1	Kü 10509.
13	39 24.73	6 0 53.9	4.46	28.7	*A.G. Lpz. II* 11748.
14	23 35 40.82	5 10 34.4	4.47	28.9	Boss' *P.G.C.* 6077.
15	0 35 13.39	11 4 47.9	0.52	3.9	Tou. ph. +11°, 0h 36m No. 103.
16	35 6.03	10 59 49.6	0.52	3.9	Tou. ph. +11°, 0h 36m No. 100.
17	0 35 24.21	11 4 55.5	0.51	3.6	Tou. ph. +11°, 0h 36m No. 105 (with μ_α = +0.009).
18	20 33 50.53	24 58 15.4	3.70	11.7	Paris ph. +24°, 20h 32m No. 223; Oxf. ph. 25° 69849.
19	32 57.88	25 19 2.0	3.73	12.2	Oxf. ph. +25° 69946, +26° 66618.
20	29 50.58	25 53 57.9	3.79	13.5	Oxf. ph. +25° 69470, +26° 66948.
21	28 32.26	26 8 31.1	3.82	14.0	Oxf. ph. +26° 66086, +26° 67056, +27° 57437.
22	23 52.25	26 37 27.3	3.87	15.8	Oxf. ph. +26° 66215, +27° 56868.
23	21 17.06	26 50 59.9	3.89	16.5	*A.G. Cambr.* 11261.
24	18 11.79	26 47 44.2	3.90	17.5	Oxf. ph. +26° 65585, +27° 56900.
25	17 20.48	26 50 15.6	3.90	17.7	Oxf. ph. +26° 65605, +27° 56931.
26	14 57.63	26 40 15.2	3.90	18.4	Oxf. ph. +26° 65551, +27° 56000.
27	7 15.15	25 37 23.5	3.86	20.7	Oxf. ph. +25° 66204, +26° 63654.
28	1 0.27	22 59 29.8	3.77	22.8	Paris ph. +22°, 20h 0m No. 295; +23°, 19h 56m No. 971; 20h 4m No. 569.
29	1 24.90	19 58 9.0	3.68	23.9	*A.G. Berl. A* 7912
30	9 37.05	14 9 46.1	3.58	24.7	*A.G. Lpz. I* 7788.
31	10 25.12	13 53 39.2	3.58	24.7	*A.G. Lpz. I* 7800.
32	16 23.06	12 25 31.0	3.57	25.0	*A.G. Lpz. I* 7853.
33	20 18 20.74	+11 25 47.4	3.55	24.9	*A.G. Lpz. I* 7880.
34	21 55 8.63	− 1 46 23.9	3.62	25.4	*A.G. Str.* 7678.
35	22 3 39.71	− 2 6 50.9	3.63	25.5	Alg. ph. −2°, 22h 0m No. 192.
36	22 13 59.75	− 2 37 23.0	3.65	25.4	*A.G. Str.* 7764.
37	23 47 23.13	− 3 57 33.2	9.85	4.0	*A.G. Str.* 8154.
38	0 47 6.10	− 2 42 15.9	0.80	2.2	Alg. ph. −2°, 0h 48m No. 60.
39	0 49 44.90	− 2 31 23.7	0.81	2.0	Alg. ph. −2°, 0h 48m No. 74.
40	1 5 58.13	− 2 1 36.8	0.83	1.5	*A.G. Str.* 261.
41	1 8 52.00	− 1 54 25.4	0.83	+ 1.4	Alg. ph. −2°, 1h 4m No. 51; 1h 12m No. 94; −1°, 1h 8m No. 36.
42	3 13 31.19	+ 3 23 12.6	0.86	− 2.3	*A.G. Alb.* 952.
43	4 34 17.37	−13 58 58.1	2.75	+18.5	Anon. 11M referred to Tac. ph. −15°, 4h 36m No. 50.
44	4 47 51.84	−13 32 51.0	2.82	17.0	*A.G. Camb. M.* 1219.
45	4 51 51.84	−13 11 8.3	2.88	16.7	*A.G. Camb. M.* 1246.
46	5 9 8.86	−12 16 21.7	+3.01	+15.1	*A.G. Camb. M.* 1360.

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
47	5 33 6.55	−10 7 38.7	+3.30	+12.2	*A.G. Camb. M.* 1526.
48	5 48 48.40	− 8 20 45.3	3.49	9.9	*A.G. Camb. M.* 1674.
49	6 0 15.57	− 6 39 47.9	3.64	8.0	*A.G. Camb. M.* 1756.
50	6 1 48.49	− 6 20 13.9	3.67	+ 7.7	*A.G. Camb. M.* 1773.
51	6 44 22.72	+ 7 48 19.4	4.62	− 3.6	*A.G. Lpz. II* 3244.
52	6 59 14.81	20 41 29.9	5.36	−10.0	*δ Geminorum* (*N. A.* 1918).
53	6 58 47.81	22 45 49.8	5.50	−10.5	Paris ph. +22°, 6^h 56^m No. 293; 23°, 7^h 0^m No. 660.
54	7 1 59.24	30 40 2.1	6.03	−12.9	Oxf. ph. +30° 18035, 31° 18319.
55	6 44 54.32	58 48 28.4	4.35	− 5.6	*A.G. Hels.* 4743.
56	6 44 33.25	59 24 6.3	4.43	− 5.4	*A.G. Hels.* 4740.
57	6 37 51.	61 43.8 . .	4.78	− 3.5	*B.D.* 61° 904.
58	6 35 36.45	62 34 50.7	4.91	− 2.8	Vat. ph. 63° 12894.
59	6 32 40.17	63 32 10.2	5.06	− 1.7	Vat. ph. 63° 13028, 64° 9491.
60	6 31 1.12	64 1 41.0	5.14	− 1.1	Vat. ph. 64° 9571; Gr. ph. 64° 2325.
61	6 30 34.70	64 17 48.6	5.18	− 0.7	Vat. ph. 64° 9609; Gr. ph. 64° 2334.
62	6 29 10.63	64 32 9.8	5.22	− 0.4	Vat. ph. 64° 9643, 9276; Gr. ph. 64° 2339.
63	6 28 6.87	64 45 49.1	5.25	0.0	Vat. ph. 64° 9322, 9675; Gr. ph. 64° 2316.
64	6 28 9.36	64 57 39.5	5.28	+ 0.3	Vat. ph. 64° 9353, 9708; Gr. ph. 64° 2324.
65	6 27 31.32	65 9 44.9	5.31	0.6	Gr. ph. 65° 2184.
66	6 27 2.66	65 45 29.0	5.38	1.6	Gr. ph. 65° 2223.
67	6 27 28.41	66 16 6.8	5.38	3.2	Gr. ph. 66° 2047.
68	6 29 17.74	66 18 18.4	5.38	3.2	Gr. ph. 66° 2103.
69	6 31 16.58	66 13 54.1	5.29	3.6	*A.G. Chr.* 1063.
70	6 57 8.70	64 55 39.5	4.78	4.5	Vat. ph. 64° 10129.
71	7 10 20.80	+63 48 40.0	+4.50	+ 4.2	*A.G. Hels.* 4981.

Remarks

☄ Wolf 1916 *b*

These observations are continued from *A.J.* 695 (1916) and *Monthly Notices R. A. S.*, Dec. 1917.

July 24. Brightness $\pm 9^M$. Small stellar nucleus $\pm 13^M$. Short fan-shaped tail; axis in 260°.

Estimations of brightness by Argelander's method (in 3-inch finder)

July 27.	*B.D.* +22° 4846 ($8^M.6$) − 3 − ☄; ☄ − 2 − *B.D.* +22° 4845 ($9^M.1$);	☄ = $8^M.9$.
Aug. 14.	*B.D.* +18° 5194 ($9^M.2$) − 1 − ☄;	☄ = $9^M.3$.
Aug. 18.	*B.D.* +16° 4968 ($9^M.3$) = ☄;	☄ = $9^M.4$.
Sept. 10.	*B.D.* + 7° 5080 ($9^M.0$) − 2 − ☄;	☄ = $9^M.2$.
Sept. 17.	*B.D.* + 5° 5213 ($8^M.9$) − 5 − ☄; ☄ − 5 − *B.D.* +4° 5042 ($9^M.5$);	☄ = $9^M.2$.

☄ Encke 1917 *c*

Mar. 2. Round nebulosity of 55″ diameter. Central condensation. Brightness in 3-inch finder: *B.D.* +10° 70 ($7^M.3$) − 5 − ☄; ☄ − 5 − *B.D.* +10° 80 ($8^M.3$); hence ☄ = $7^M.8$.

☄ Wolf 1918 *b*

1918 July 27. Stellar condensation $14^M.0$. Total brightness $13\frac{1}{2}^M$.
Aug. 3. Stellar condensation $14\frac{1}{2}^M$. Total $13\frac{1}{2}^M$.
Aug. 4. Short tail about 15″ in 190°.
Aug. 31. Total brightness $13\frac{1}{2}^M$; stellar nucleus 14^M; tail 35″ in 170°.
Sept. 28. Total brightness 13^M; stellar nucleus $14\frac{1}{2}^M$; tail in 148°.
Oct. 3. Total brightness 13^M; nucleus $\pm 15^M$; sharply defined fan-shaped tail in 135°.

Comet Wolf 1918 *b* (*Continued*)

1918	Oct. 6.	Total brightness $12\frac{1}{2}^M$; diffuse nucleus $\pm 11^M$; tail like a short fan of 120° opening.
	Nov. 30.	Brightness 11^M; nucleus 13^M; round nebulosity.
1919	Jan. 3.	Brightness 12^M; sharp nucleus 13^M; round nebulosity.
	Jan. 24.	Round nebulosity 1′ in diameter.
	Mar. 21.	Diffuse extended nebulosity; total brightness about $13\frac{1}{2}^M$. Near limit of twelve-inch instrument.

Comet Borrelly 1918 *c*

1918	Aug. 31.	Total brightness 13^M; tail 35″ in 95°; nucleus elongated in same direction.
	Sept. 15.	Interrupted by clouds.
	Sept. 28.	Total brightness 12^M; nucleus $14\frac{1}{2}^M$.
	Oct. 6.	Total brightness $11\frac{1}{2}^M$; nucleus 13^M; tail 90″ in 90°, just in the direction of the *Sun!*
	Oct. 12.	10^M; nucleus 12^M; tail 70″ in 90°.
	Oct. 13.	Smoky atmosphere; tail 75″ in 90°.
	Oct. 16.	Tail in 95°.
	Nov. 10.	$10\frac{1}{2}^M$; tail about 4′ in 100°.
	Nov. 24.	11^M; nucleus 12^M; tail in 85° but very dissymmetrical; the nucleus is near the southern edge of the nebulosity.
	Dec. 3.	Total brightness in 3-inch finder: Comet = *B.D.* 30° 1421 ($9^M.1$). Nebulosity extends symmetrically 2′ east and west of the nucleus, but only 1′ toward the north and ½′ towards the south.
1919	Jan. 3.	Very elongated nebulosity, the ratio of the two axis being about 5 to 1; major axis in 50°; the nucleus nearly in the center.
	Jan. 24.	Brightness about 12^M. Small round nebulosity about 15″ in diameter; central nucleus.
	Jan. 31.	Brightness $11^M.5$; nucleus $12^M.5$; central condensation.
	Feb. 23.	Brightness 13^M.
	Mar. 3.	Brightness $13\frac{1}{2}^M$.

Williams Bay, Wisconsin, May, 1919.

NOTE ON APPARENT PLACE OF ASTEROIDS AND COMETS.

By E. MILLOSEVICH,

[From a letter to the Editor.]

I read in No. 750 of the *Astronomical Journal* the note of Mr. E. C. Bower "On Apparent Place of Asteroids and Comets."

It is also my opinion that the apparent place reduction of the stars referred to is dispensable with equatorial observations, the more so as dR is negligible except in exceptional cases, and on the other hand the small correction can be noted annually.

It also seems opportune to mention the complete discussion of the question by the late astronomer Ristenpart (*A. N.* 3832—3833).

If all the visual observations and the photographic measures referred to a given star are presented in the aforesaid form, the place of a planet or of a comet referred to the mean equinox of the beginning of the year, as is the place of a star, is free from the differential effect of precession, of nutation, and aberration of the fixed stars, and the place observed from the *Earth* at the time T_1 corresponds to the heliocentric place of the star at time T_0, where $T_1 - T_0 = 498^s.65\,\Delta$, Δ being the distance of the movable star from the *Earth*.

Therefore in order to compare the observed place with the ephemeris calculated according to this criterion, the time observed, corrected for the longitude to adapt it to the meridian of the ephemeris, must not be further corrected for the aberration time, because the ephemeris is calculated from the heliocentric place at the time T_0, while the coördinates of the *Sun* are for the time T_1. Consequently a value of Δ has been assumed sufficiently exact not to require revision in the first approximations of the orbit, but may require revision in the calculation of a definitive orbit.

Royal Observatory, Rome, May 10, 1919.

OCCULTATIONS BY THE *MOON*,

OBSERVED WITH THE 26-INCH AND 12-INCH EQUATORIALS OF THE U. S. NAVAL OBSERVATORY

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. N., Superintendent.]

Date		Object	Phen	26-Inch						12-Inch					
				W. Sid. T.	W. M. T.	See'g	Rem	Pow'r	Obs	W. Sid. T.	W. M. T.	See'g	Rem	Pow'r	Obs.
1918				h m s	h m s					h m s	h m s				
July	20	51 *Ophiuchi*	DD	15 20 45.9	7 28 52.0	p	1	178	HL						
	20	51 *Ophiuchi*	RB	16 37 2.3	8 44 55.9	p	2	178	HL						
	31	*A Tauri*	DB	23 53 12.3	15 16 39.4	p		178	HL	23 53 11.4	15 16 38.5	f	3	115	B
Sept.	19	*κ Piscium*	DD	0 6 19.3	12 13 8.9	f	4	178	HL	0 6 19.3	12 13 8.9	p	5	160	BN
	19	9 *Piscium*	DD	0 21 52.8	12 28 39.8	f	4	178	HL	0 21 53.0	12 28 40.1	p	6	160	BN
	24	67 *Tauri*	DB							0 15 17.5	12 2 26.1	f	7	160	B
	24	67 *Tauri*	RD	1 4 14.1	12 51 14.7	f		183	BN						
Nov.	8	*ξ Sagittarii*	DD	20 52 51.0	5 43 37.0	f	8	183	BN	20 52 51.2	5 43 37.1	p	9	115	B
	8	*ξ Sagittarii*	RB	21 37 51.9	6 28 30.5	f	6	178	BN						
	8	36 *Sagittarii*	DD	21 14 0.3	6 4 42.8	f	6	183	BN	21 14 0.5	6 4 43.0	p	10	115	B
	18	247 *B. Tauri*	DD	1 11 46.8	9 22 31.2	p	11	178	BN						
	18	247 *B. Tauri*	RD	1 49 13.7	9 59 52.0	p		178	BN						
	25	55 *Leonis*	DB	5 55 2.0	13 37 28.6	vp	12	178	BN						
	25	55 *Leonis*	RD	7 0 32.2	14 42 48.1	vp	12	183	BN	7 0 32.5	14 42 48.4	p	13	115	B
Dec.	7	27 *G. Capricorni*	DD							23 4 47.8	6 1 10.6	p	5	115	BN
	19	5 *Cancri*	DB	2 35 36.2	8 44 13.6	p		178	HL	2 35 37.3	8 44 14.7	p	12	160	BN
	19	5 *Cancri*	RD	3 37 26.0	9 45 53.3	f	14	178	HL	3 37 25.3	9 45 52.6	f		160	BN
1919															
Jan.	7	19 *Piscium*	DD	1 37 16.4	6 31 21.1	f	15	183	HL	1 37 16.6	6 31 21.3	f	9	115	B
	7	19 *Piscium*	RB	2 43 12.1	7 37 35.9	f	16	178	HL						
	10	27 *Arietis*	DD	1 53 29.3	6 35 43.6	f		178	HL	1 53 29.4	6 35 43.6	p	10	160	B
	10	27 *Arietis*	RB	2 14 8.5	6 56 19.4	p	17	178	HL						
	11	14 *H.*[1] *Tauri*	DD	6 21 3.4	10 58 37.9	g		178	HL	6 21 3.5	10 58 38.0	f	10	115	B
	11	14 *H.*[1] *Tauri*	RB							7 4 7.2	11 41 34.6	f	18	115	B
	11	22 *H.*[1] *Tauri*	DD	8 50 49.0	13 27 59.0	f		178	HL	8 50 49.0	13 27 59.0	p	10	115	B
	11	22 *H.*[1] *Tauri*	RB							9 34 15.2	14 11 18.0	p	19	115	B
	15	*f Geminorum*	DD	5 25 33.9	9 47 33.9	p	4	178	HL	5 25 33.7	9 47 33.6	p	20	160	B
	15	*f Geminorum*	RB	6 35 11.4	10 56 59.9	f	2	178	HL	6 35 10.7	10 56 59.2	f	21	160	B
	19	*p^3 Leonis*	DB	7 0 18.2	11 6 19.0	p		178	HL						
	19	*p^3 Leonis*	RD	8 4 29.5	12 10 19.8	f		183	HL						
Feb.	8	51 *Tauri*	DD							4 35 1.6	7 22 48.0	f	22	115	BN
	8	56 *Tauri*	DD							5 31 13.4	8 18 50.6	f	26	115	BN
	10	15 *Geminorum*, comp.	DD	10 5 27.2	12 44 27.6	f		183	HL						
	10	15 *Geminorum*	DD	10 6 14.2	12 45 14.5	f	14	183	HL	10 6 14.3	12 45 14.6	f		115	BN
	10	15 *Geminorum*	RB							11 0 12.7	13 39 4.2	f		160	BN
	10	16 *Geminorum*	DD	10 19 19.1	12 58 17.3	f		183	HL	10 19 19.1	12 58 17.2	f	5	115	BN
	10	16 *Geminorum*	RB							11 15 20.0	13 54 9.0	p		160	BN
Mar.	11	2 *B. Cancri*	DD	7 46 26.1	8 31 48.0	f	23	183	BN						
	11	2 *B. Cancri*	RB	8 53 20.0	9 38 31.0	p		178	BN						
	12	*α Cancri*	DD	13 14 35.6	13 55 7.8	f		178	HL	13 14 35.7	13 55 7.9	f	9	115	B
	12	*α Cancri*	RB	13 57 14.4	14 37 39.6	f	24	178	HL	13 57 8.7	14 37 34.0	p	25	160	B
	21	128 *B. Sagittarii*	RD	15 11 5.0	15 4 7.3	f	27	183	HL	15 11 5.0	15 4 7.2	f		160	BN
Apr.	8	*A*[1] *Cancri*	DD	13 18 37.1	12 12 59.2	f	28	183	HL	13 18 37.2	12 12 59.3	p	9	115	B
	9	*ω Leonis*	DD							10 31 5.1	9 21 58.7	p	29	115	B
	21	226 *B. Sagittarii*	DB	16 7 4.7	14 9 52.4	p		178	HL	16 7 3.9	14 9 51.6	p	20	160	B

Date	Object	Phen.	26-Inch						12-Inch					
			W. Sid. T.	W. M. T	See'g	Rem	Pow'r	Obs	W. Sid. T.	W. M. T.	See'g	Rem	Pow'r	Obs.
1919			h m s	h m s					h m s	h m s				
Apr. 21	226 *B. Sagittarii* . .	RD	17 29 19.5	15 31 53.7	f	. .	183	HL	17 29 19.5	15 31 53.7	f	35	115	B
May 17	14 *Sagittarii* . .	RD	18 40 3.4	15 0 12.4	p	28	183	HL	18 10 3.2	15 0 12.2	p	. .	115	Bx
June 2	60 *Cancri*	DD	13 36 50.6	8 54 54.7	f		183	Bx	13 36 50.8	8 51 51.9	f	10	115	B
16	27 *G. Capricorni* . . .	DB	15 53 53.8	10 16 32.7	p	30	178	Bx	15 53 53.6	10 16 32.5	p	31	115	B
16	27 *G. Capricorni* . . .	RD	17 4 18.4	11 26 45.8	p	32	183	Bx	. . . . .	. . . . .	. .	. .	. .	. .
23	*π Arietis*, brighter comp.	DB	21 11 55.1	15 6 10.5	p	12	178	Bx	21 11 51.2	15 6 6.6	f	33	115	B
23	*π Arietis*, brighter comp.	RD	22 7 0.1	16 1 6.5	p	34	183	Bx	22 7 0.3	16 1 6.7	f	10	115	B

Phenomena: DD = disappearance at dark limb; DB = disappearance at bright limb; RD = reappearance at dark limb; RB = reappearance at bright limb.

Seeing: g = good; f = fair; p = poor; vp = very poor.

Observers: HL = A. HALL; Bx = H. E. BURTON; B = ERNEST CLARE BOWER.

REMARKS

(1) Twilight. (2) Late 2^s. (3) Late ? $\pm 3^s$. Clouds. (4) *Moon* nearly full. (5) Thin clouds. (6) Haze. (7) Late $1^s \pm 2^s$. (8) Dark limb visible. Haze. (9) Late $0^s.1$. (10) Late $0^s.15$. (11) Gradual. Haze. (12) Gradual. (13) Late $0^s.1$. Gradual. (14) Late $0^s.3$. (15) Dark limb visible. (16) Late $0^s.5$. (17) Late 3^s. (18) Late $4^s \pm$. Clouds. (19) Late $3^s \pm$. (20) $\pm 3^s$. (21) Late $2^s \pm$. (22) Gradual. Thin clouds. (23) A little haze. (24) Through haze and clouds. Late several seconds. (25) Late $3^s \pm 1^s$. Cloudy. (26) Through thin cloud. (27) Dark limb visible, a trifle late. (28) Late $0^s.2$. (29) Star nearly disappeared about 3^s before disappearance, then brightened to normal. Late $0^s.15$. Clouds. (30) Gradual. Uncertain. (31) $\pm 4^s$. (32) Thin clouds. Perhaps late. (33) Early $1^s \pm 2^s$. (34) Dark limb visible. Dawn. (35) Late $0^s.15$. Sheet marked 2^m earlier.

NOTE. All observations were recorded on chronograph. Occulting bars were attached to eyepieces of powers 178 and 160

Washington, D. C., 1919 June 24.

A FAINT DISTANT COMPANION TO *B. D.* +7°2690,

BY ROBERT TRUMPLER.

In the course of a determination of the parallax of the sixth magnitude star *B. D.* +7° 2690 from plates taken with the Thaw Photographic Refractor of the Allegheny Observatory, it was found that the proper-motion in right ascension of this star relative to four faint comparison stars, came out considerably smaller than the proper-motion given in Boss' *Preliminary General Catalogue*. It was immediately suspected that one of the comparison stars might share the large proper-motion of the parallax star. A special examination of the plates proved that this is the case and led to the discovery that the star *B. D.* +7° 2692 is a faint and distant companion to the star *B. D.* +7° 2690.

The parallax plates were then remeasured with other comparison stars so selected as to allow a determination of the parallaxes of both components. The fact that the resulting parallaxes, given in the table below, are nearly equal, furnishes another proof of the physical connection between the two stars.

In order to obtain an accurate value of the relative position and proper-motion of the two components, two of our parallax plates were measured in both coördinates. For the determination of the plate constants, eight reference stars were used, the positions of which were taken from a reduction of the plate 103 of the *Astrographic Catalogue Toulouse*, Zone +6° — +8°, Vol. IV, page A115. This plate of the *Astrographic Catalogue* contains both components of our system and furnishes therefore another determination of their relative position.

The results for the position of the fainter star relatively to the brighter for equinox and equator 1900.0 are:

Astr. Cat. Toulouse, plate 103	$\Delta\alpha = +31^s.668$,	$\Delta\delta = -2' 6''.97$,	Epoch 1909.38
Allegheny plate 1328	.658	7 .04	1915.16
11830	.666	6 .94	1918.04

Giving the last two plates twice the weight of the first, we obtain by least squares solutions:

$\Delta\alpha = +31^s.663$, $\Delta\delta = -2' 6''.99$ for the mean epoch 1915.2, or distance 488''.37 in position angle 105° 4'.3, and the relative annual proper-motion

$$\mu_\alpha = -^s.0003 \quad \mu_\delta = +''.003$$

From our parallax plates the photographic magnitude of the companion was derived by comparing it with the principal star, taking account of the opening of the rotating sector, and using for the photographic magnitude of the bright star the visual magnitude increased by the mean color index corresponding to its spectral type. A similar plate taken with a yellow color filter on an orthochromatic plate though very weak, allowed an estimate of the visual magnitude and of the color index of the companion. The latter is about 0.5 magnitudes larger than for the bright star and indicates a spectral type between *G*5 and *K*0 for the companion.

Using for the principal star the position and proper-motion of Boss' *Preliminary General Catalogue* and the visual magnitude and spectral type of the *Harvard Revised Photometry*, we have the following data for the two components of our system:

	Brighter component	Fainter component
Right ascension (Epoch and Equinox 1900)	$13^h 42^m 0^s.043$	$13^h 42^m 31^s.711$
Declination (Epoch and Equinox 1900)	+6° 51' 11''.87	+6° 49' 4''.93
Annual proper-motion in R. A.	$-^s.0326$	$-^s.0329$
Annual proper-motion in Declination	−''.115	−''.112
Total proper-motion	''.499	''.503
Relative parallax	+''.023 ± ''.006 (3)	+''.026 ± ''.008
Spectral Type	*F*5 (3)	*G*5 — *K*0
Visual magnitude	6.32	10.1 (1)
Photographic magnitude	6.7 (2)	11.0 (2)
Absolute magnitude (visual)	+4.2 (3)	+8.0

Projection of linear distance between components, 13200 astr. units, or 0.064 parsecs.

(1) The *B. D.* magnitude of this star is 9.3, which corresponds to 10.0 on the Harvard scale (reduction from *H. A.*, Vol. LXXII, page 215).

(2) The *Astrographic Catalogue* gives 7.8 and 12.0 for the photographic magnitudes of the two stars, which evidently have to be corrected by −1.0 magnitude in order to agree with the Harvard system.

(3) Adams and Joy (Contr. from the Mount Wilson Solar Observatory, No. 142) give *F*9 for the spectral type, +4.7 for the absolute magnitude and +''.048 for the parallax of the brighter star, as determined by the spectroscopic method.

Taking the mean of the relative parallaxes of both components (''.024) and increasing it by the average parallax of the comparison stars (''.003) we obtain ''.027 as result of the trigonometric method. Adopting the mean of the results of the trigonometric and the spectroscopic method (+''.037) as the most probable value of the parallax, we compute the absolute magnitudes in the table and the projection of the linear distance between the components.

The large distance between the components is remarkable and is similar to that of Innes' companion to *α Centauri*.

Allegheny Observatory of the University of Pittsburgh, June 21, 1919.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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OBSERVATIONS OF ASTEROIDS,

MADE WITH THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY,

By GEORGE H. PETERS.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Name	Mag.	Date, 1918	G. M. T.	Astrographic 1918.0 α	Astrographic 1918.0 δ
			h m	h m s	° ′ ″
886 1917 *W 15*	12.0	Jan. 9	12 37.1	2 31 31.98	+14 56 14.8
342 *Endymion*	12.1	10	14 26.7	5 04 34.74	+15 21 26.2
342 *Endymion*	12.1	15	14 01.6	5 02 31.27	+15 11 46.6
32 *Pomona*	10.6	19	14 51.1	6 06 11.83	+15 59 59.9
84 *Klio*	12.5	Feb. 11	16 19.4	9 49 30.56	+14 04 10.8
600 *Musa*	13.1	11	16 19.4	9 52 34.46	+14 22 01.2
30 *Urania*	10.2	11	16 19.4	9 53 31.43	+11 43 29.4
84 *Klio*	12.5	12	16 20.6	9 48 26.04	+14 07 34.2
600 *Musa*	13.1	12	16 20.6	9 51 43.42	+14 30 25.0
375 *Ursula*	11.5	Mar. 2	14 41.8	9 52 36.20	+16 03 19.2
169 *Zelia*	12.1	2	15 50.3	10 11 53.96	+14 24 54.8
375 *Ursula*	11.5	5	14 25.8	9 50 10.32	+16 04 29.1
308 *Polyxo*	11.2	5	16 16.3	10 03 49.56	+ 8 41 10.8
169 *Zelia*	12.1	5	15 19.8	10 08 56.76	+14 34 21.9
78 *Diana*	9.4	11	15 16.1	9 58 45.55	+11 04 44.8
308 *Polyxo*	11.2	11	15 16.1	9 59 30.80	+ 9 15 06.7
64 *Angelina*	9.9	11	15 58.6	10 56 17.33	+ 5 22 10.8
385 *Ilmatar*	9.5	11	15 58.6	11 02 34.11	+ 5 30 17.5
65 *Cybele*	10.9	11	15 58.6	11 12 53.03	+ 4 34 28.3
65 *Cybele*	10.9	15	15 51.9	11 09 53.11	+ 4 52 00.4
17 *Thetis*	10.1	15	15 51.9	11 17 13.70	+ 5 39 24.6
184 *Dejopeja*	12.1	15	15 51.9	11 20 08.37	+ 3 20 07.6
91 *Ægina*	10.7	15	15 51.9	11 21 04.60	+ 5 28 50.0
65 *Cybele*	10.9	17	16 44.2	11 08 22.92	+ 5 00 44.9
17 *Thetis*	10.1	17	16 44.2	11 15 50.72	+ 5 49 52.2
184 *Dejopeja*	12.1	17	16 44.2	11 18 19.26	+ 3 28 41.0
91 *Ægina*	10.7	17	16 44.2	11 19 16.33	+ 5 38 20.2
198 *Ampella*	9.6	Sept. 9	15 47.1	22 09 13.06	+ 8 25 14.6
276 *Adelheid*	11.8	Nov. 5	16 15.7	2 02 09.80	+10 04 07.2
276 *Adelheid*	11.8	6	16 28.2	2 01 28.23	+ 9 54 14.0
125 *Liberatrix*	11.5	25	16 01.5	3 13 30.30	+11 28 00.6
125 *Liberatrix*	11.5	26	15 24.5	3 12 42.09	+11 24 53.5
429 *Lotis*	11.8	27	14 19.8	2 36 11.28	+12 12 25.3

Name	Mag.	Date, 1918	G. M. T.	Astrographic 1918.0 α	Astrographic 1918.0 δ
			h m	h m s	° ′ ″
540 *Rosamunde*	12.4	Nov. 27	15 21.9	3 23 35.62	+12 49 10.9
100 *Hekate*	12.1	27	16 21.4	3 41 14.36	+10 49 25.5
429 *Lotis*	11.8	29	14 27.1	2 34 33.04	+11 51 49.4
540 *Rosamunde*	12.4	29	15 22.7	3 20 39.12	+12 33 22.8
100 *Hekate*	12.1	Dec. 5	15 00.3	3 35 05.56	+10 39 50.1

Owing to my absence from Washington during considerable periods in 1918, the above list of asteroids is not very extensive.

Official duties, involving travel, in connection with war preparation by the Navy occupied much of the time.

A month was required also, as a member of the Naval Observatory eclipse expedition, to observe the total solar eclipse of June 8th, at Baker, Oregon.

Asteroid 1917 *W15* has been recognized as new in European publications, receiving the provisional designation (886) [1917 *b*].

The name *Washingtonia* was also adopted. The magnitude given for this asteroid is the estimated brightness for time of discovery, near opposition.

OBSERVATIONS OF MINOR PLANETS,

MADE WITH THE 12-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Date	Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log $p\Delta$ α	Log $p\Delta$ δ	Red. to App. Pl. α	Red. to App. Pl. δ	Seeing	Obs.
						(1) *Ceres*							
1915	h m s			m s	′ ″	h m s	° ′ ″			s	″		
Oct. 28	12 31 1	1	25, 5	+2 1.23	+ 9 11.8	3 44 15.17	+11 4 54.8	8.980*n*	0.613	+4.63	+22.6	g	B
						(2) *Pallas*							
1914													
Jun. 30	11 51 51	2	25, 5	−2 30.21	− 2 6.0	19 46 19.67	+20 28 58.0	9.227*n*	0.462	+2.91	− 2.8	g	B
						(3) *Juno*							
1915													
Mar 10	12 43 30	3	45, 15	+0 46.90	− 7 53.0	11 5 15.64	+ 4 30 39.5	8.992	0.695	+2.53	−13.7	f-p	WR
17	10 38 28	4	30, 6	+2 32.51	+ 3 53.2	10 59 53.32	+ 5 37 12.5	8.932*n*	0.682	+2.54	−13.3	g	WR
						(4) *Vesta*							
1912													
Mar. 10	11 54 2	5	25, 5	−5 56.95	− 0 21.6	9 47 39.97	+22 43 37.1	9.231	0.412	+1.71	− 1.3	f	Ws
Apr. 3	9 5 20	6	15, 5	−2 11.01	− 1 11.7	9 37 52.95	+23 11 35.4	8.529	0.373	+1.48	+ 1.7	p	Ws
6	9 57 20	6	14, 5	−2 9.85	− 5 59.2	9 37 54.09	+23 6 48.0	9.228	0.402	+1.46	+ 1.8	p	Ws
1915													
Feb. 8	10 54 3	7	30, 6	+3 35.10	+ 0 8.8	4 27 14.49	+19 33 32.2	9.598	0.587	+1.48	+ 9.9	f	WR
10	9 10 42	8	25, 5	+2 43.07	+ 1 21.4	4 28 2.92	+19 40 54.7	9.395	0.504	+1.48	+ 9.9	g	WR
27	9 39 25	9	30, 6	+2 45.88	+ 3 18.9	4 39 6.26	+20 48 13.0	9.585	0.561	+1.29	+ 9.8	p,u	WR
1916													
Apr. 15	12 37 16	10	25, 5	−3 42.53	− 8 6.6	13 35 10.74	+ 3 19 19.3	8.881	0.702	+2.96	−19.6	f	B
29	13 3 12	11	25, 5	+6 8.32	− 0 53.8	13 22 42.60	+ 4 32 55.8	9.397	0.701	+3.00	−18.4	f	B
May 31	9 26 55	12	25, 5	−1 39.93	−12 9.8	13 9 39.51	+ 3 17 13.2	9.031	0.708	+2.91	−16.2	f	B

Seeing: g = good, f = fair, p = poor, u = unsteady.

Observers: Ws = C. B. WATTS; B = ERNEST CLARE BOWER; WR = A. G. WEBSTER, JR.

Mean Places of Comparison Stars for the Beginning of the Year.

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	3 42 9.31	+10 55 20.4	*A.G. Leipzig I*	1094	7	4 23 37.91	+19 33 13.5	*A.G. Berlin A*	1187
2	19 48 46.97	+20 31 6.8	*A.G. Berlin B*	7332	8	4 25 18.37	+19 39 23.4	*A.G. Berlin A*	1198
3	11 4 26.21	+ 4 38 46.2	*A.G. Albany*	1206	9	4 36 19.09	+20 44 44.3	*A.G. Berlin B*	1492
4	10 57 18.27	+ 5 33 32.6	*A.G. Leipzig II*	5662	10	13 38 50.31	+ 3 57 45.5	*A.G. Albany*	4781
5	9 53 35.21	+22 44 0.0	*A.G. Berlin B*	3889	11	13 16 31.28	+ 4 34 8.0	*A.G. Albany*	4699
6	9 40 2.48	+23 12 45.4	*A.G. Berlin B*	3834	12	13 11 16.53	+ 3 29 39.2	*A.G. Albany*	4672

Notes. All observations except those on 1915 Oct. 28, 1916 Apr. 15, Apr. 29, and May 31 are practice observations. 1914 June 30, volunteer observation. 1915 Feb. 8, haze. 1916 Apr. 15, perhaps the sidereal time of observation should be decreased 1^M 1916 Apr. 29, poor observation.

Washington, D. C., 1919 June 20.

THE PROBABLE ERRORS OF PROPER-MOTIONS EXPRESSED IN POLAR COÖRDINATES,

By FRANK SCHLESINGER.

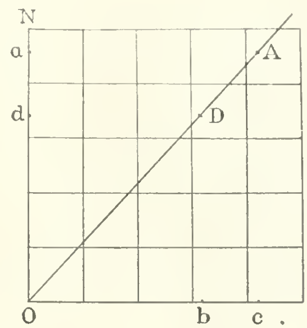
Having derived from star catalogs the proper-motions of a star in right ascension and declination, together with their probable errors, the computer often has occasion to transform these into polar coördinates, position angle and distance. Our problem is to devise means for facilitating the computation of the probable errors of the polar coördinates. This problem was suggested by the late Professor Pickering in connection with his extensive work on proper-motions that has just appeared in Volume LXXXI of the *Harvard Annals*.

Let μ_α, be the proper-motion in right ascension.
μ_δ, the proper-motion in declination.
μ, the proper-motion in arc of a great circle.
$\mu\phi$, the proper-motion in position angle.
ϵ_α, ϵ_δ, ϵ, $\epsilon\phi$, the probable errors of these four quantities, expressed in arcs of great circles.

We then have

$$\tan\phi = \mu_\alpha/\mu_\delta$$
$$\mu = \mu_\alpha \sec\phi = \mu_\delta \operatorname{cosec}\phi$$
$$\epsilon^2 = \epsilon^2_\alpha \sin^2\phi + \epsilon^2_\delta \cos^2\phi$$
$$\epsilon^2\phi = \epsilon^2_\alpha \cos^2\varphi + \epsilon^2_\delta \sin^2\phi$$

If we have a large number of these probable errors to compute we might construct a table with the position angle and the ratio between μ_α and μ_δ as the arguments. This table would give factors which when multiplied by ϵ_α (or ϵ_δ) would yield ϵ and $\epsilon\phi$. The following graphical process, however, is shorter and is sufficiently accurate in all cases.



On ordinary coördinate paper lay off NOA equal to ϕ; then lay off OA equal to the probable error in right ascension, and OD equal to the probable error in declination. Project both of these into the two axes at a, b, c and d. The probable error in distance (ϵ) is equal to ab, while the probable error in the position angle ($\epsilon\phi$) is dc. The latter is expressed in arc of a great circle. If we desire to have it in degrees, we multiply $\epsilon\phi$ by $57.3\ \mu$.

If the proper motion is not large we may derive μ and $\mu\phi$ themselves by a graphical process. In this case the additional labor in applying the above graphical method to the derivation of ϵ and $\epsilon\phi$ is very slight indeed.

Allegheny Observatory, The University of Pittsburgh, May 13, 1919.

PRELIMINARY PARALLAX AND MAGNITUDES OF *NOVA AQUILÆ* 3,

By CHARLES P. OLIVIER.

Nova Aquilæ 3 was independently discovered by the writer on 1918 June 8, at $15^h\ 20^m$ G. M. T. From that date until the middle of July, when he left to undertake work for the War Department at Aberdeen Proving Ground, Md., observations were made on every possible night to determine its magnitude. Other observations, included in this paper, were also made by Dr. H. L. Alden and Prof. R. C. Lamb of our staff, and these were continued by Dr. Alden until he too left in August to undertake work for the Navy Department. The writer was fortunate in getting observations on twenty-two nights up to and including July 9, during which interval the *Nova* was at its brightest. Also when observing on June 7, about 18^h G. M. T., there was occasion for examining the sky for a few minutes in the region including *Aquila*. Had the *Nova* been of the third or possibly even the fourth magnitude that night, it could scarcely have escaped recognition. This negative observation is added to give additional proof, if any is needed, that the persons in Europe who claimed to discover the *Nova* on June 7 certainly did not do so.

Being on June 8 a mile or more from the Observatory when the *Nova* was first discovered, and there being much delay in getting off a telegram to Harvard College Observatory to announce it, word could not be gotten to the observer at the 26-inch telescope until about 17^h G. M. T. However, the region was then at once examined and three parallax plates taken, the first being exposed before 18^h G. M. T. This gave us the earliest possible data for parallax. Five more plates were taken on succeeding nights, making eight for the first epoch. Unfortunately, however, due to the date of discovery, the average parallax factor for the first epoch is only about 0.3. Five plates were taken in the second epoch with average parallax factors of 0.9, and eight plates in the third with average parallax factors of 0.8. As we do not care to make a final least-square solution for parallax until at least two more epochs have been added, the results for our plates to date have been taken and an approximate solution worked out. This gives a relative parallax for *Nova* of $+0''.004$, or, adding as usual $+0''.005$, the assumed average parallax for comparison stars of 9 magnitude, to turn this into absolute parallax, we get for the latter $+0''.009$, corresponding to a distance of about 360 light years.

It is emphasized that this value is purely preliminary and is subject to change when plates of later epochs are added. This remark is particularly true in the case of *Nova* because the brightness of the star was so great at first that we were unable to cut down our rotating sector enough to give an image as small as we desired. Also with a very brilliant star guiding errors are more harmful. Possible sources of error were thus introduced in our first epoch which later epochs will show up, should they exist at all. We appear to get a slightly larger value for the proper-motion than that just obtained by Trumpler at Allegheny Observatory from a comparison of a plate taken last summer with several taken in former years.* If this difference is real, it could be explained by an actual change in the velocity and hence the proper-motion of *Nova* after the outburst, assuming that this was actually caused by collision. *Nova* has been measured here with regard to three comparison stars, *B. D.* $+0^\circ.4022$ of $9^m.3$, *B. D.* $+0^\circ.4023$ of $8^m.5$, and *B. D.* $+0^\circ.4028$ of $9^m.0$. Definitive values of the parallax and proper-motion will be published when two or more additional epochs have been added.

On 1919 April 21, the first time *Nova* was seen by the writer since July, 1918, when taking plates for our third epoch, the seeing was exceptionally good and it was at once noted that *Nova* showed an image quite different from that of similar surrounding stars, as seen in the 26-inch. It was of a brilliant sea-green color and certainly presented a disc-like appearance. This disc was estimated at about $1''$ in diameter. *Nova* was then about 7 magnitude. It was examined on several other dates in April and May and on each occasion showed a disc, though meantime its brightness had decreased. Since making these observations an article by Prof. E. E. Barnard has appeared in which he gives a series of actual measurements of the disc, which he noted as early as last fall.

The observations for magnitude made by R. C. Lamb and the writer were all reduced using the values for the comparison stars given in *Annals H. C. O.*, Vol. L. Those made by H. L. Alden were reduced using the same values when possible, but in the latter part of his list he frequently put down only the resulting magnitude, which was gotten directly from the small map, issued last summer from Harvard College Observatory, and which covered the region around *Nova*. The observations by the writer contain notes on the condition of the sky near *Nova*, which permitted weights to be assigned to the observations. Similar notes were added by him for the other observers when sufficient data were found in their records. All observa-

*See *A. J.* No. 752.

tions here published were made with the naked eye. On 1918 June 8, as seen in the 26-inch, the color of *Nova* was a brilliant blue-white, on June 9 intensely white with a trace of blue. As stated above, during April and May of this year, it was a brilliant sea-green.

Date			G. M. T.	Observations by C. P. O.	Sky	Wt.	Magn.
			h m				
1918	June	7	18	Certainly not bright enough to notice	Clear	0	<4.0
		8	15 20	*N* $0^{m}.4$ > α *Aquilæ*	Clear	3	0.19
			17 10	*N* $0^{m}.4$ > α *Aquilæ*	Clear	3	0.49
			18 30	α *Lyræ* − 5 − *N* − 4 − α *Aquilæ* − 5 − α *Cygni*	Clear	3	0.56
			20 40	α *Lyræ* − 3 − *N* − 4 α *Aquilæ*	Clear	3	0.56
			20 40	α *Lyræ* − 3 − *N* − 5 α *Aquilæ*	Clear	3	0.44
		9	14 00	*N* $0^{m}.4$ > α *Lyræ*	In haze	1	−0.26
			16 00	*N* − 12 − α *Lyræ* − 9 − α *Aquilæ*	Clear	3	−0.86
		10	14 10	α *Lyræ* 0.3 > *N*	In haze	1	0.44
			15 10	α *Lyræ* = *N*	Clear	3	0.14
		11	16 20	α *Lyræ* − 2 − *N* − 8 − α *Aquilæ*	Clear	3	0.29
			18 20	α *Lyræ* − 4 − *N* − 6 − α *Aquilæ*	Clear	3	0.44
			19 25	α *Lyræ* − 4 − *N* − 7 − α *Aquilæ*	Clear	3	0.41
		12	15	*N* $0^{m}.4$ > α *Aquilæ*	Clear	3	0.49
		13	15 54	α *Aquilæ* − 2 − *N* − 2 − α *Cygni*	Clear	3	1.44
		14	19	α *Aquilæ* 0.6 > *N*	In haze	1	1.49
		15	14 20	α *Cygni* − 6 − *N* − 4 − γ *Cygni*	In haze	1	1.92
			14 50	α *Cygni* − 5 − *N* − 5 − γ *Cygni*	Clear	3	1.82
		16	16	α *Ophiuchi* = *N*	In haze	1	2.14
		19	14 06	α *Oph.* − 5 − *N* − 3 − β *Oph.*	Clear	3	2.64
			20 0	α *Oph.* − 5 − *N* − 3 − β *Oph.*	Clear	3	2.64
		22	20	α *Oph.* − 6 − *N* − 2 − β *Oph.*	Clear	3	2.74
		23	14	β *Oph.* = *N*	Clear	3	2.94
			18	β *Oph.* = *N*	Clear	3	2.94
			21	β *Oph.* = *N*	Clear	3	2.94
		27	14 42	η *Serpentis* − 4 − *N* − 2 − θ *Serp.*	Clear	3	4.00
		28	14 0	η *Serp.* − 4 − *N* − 3 − θ *Serp.*	Clear	3	3.85
			15 30	η *Serp.* − 4 − *N* − 3 − θ *Serp.*	Clear	3	3.85
		30	15 0	η *Serp.* = *N*	S. haze	2	3.42
	July	1	19 0	η *Serp.* = *N*	Clear	3	3.42
		2	17 0	β *Oph.* − 3 − *N* − 1 − η *Serp.*	Clear	3	3.30
		3	18 0	β *Oph.* − 1 − *N* − 3 − η *Serp.*	Clear	3	3.06
		4	15	*N* $0^{m}.1$ > η *Serp.*	S. haze	2	3.32
		6	16 42	η *Serp.* = *N*	Clear	3	3.42
		8	15 06	η *Serp.* $0^{m}.2$ > *N*	Haze?	2	3.62
		9	16 30	η *Serp.* − 3 − *N* − 7 − θ *Serp.*	Clear	3	3.78

Date			G. M. T.	Observations by R. C. L.	Sky	Wt.	Magn.
			h m				
1918	June	8	18 50	α *Lyræ* − 5 − *N* − 2 − α *Aquilæ*	Clear	3	0.68
			20 30	α *Lyræ* − 3 − *N* − 4 − α *Aquilæ*	Clear	3	0.46
			21 15	α *Lyræ* − 3 − *N* − 4 − α *Aquilæ*	Clear	3	0.46
	June	9	17 0	*N* − 6 − α *Lyræ* − 8 − α *Aquilæ*	Clear	3	−0.42
		13	15 54	α *Aquilæ* $0^{m}.2$ > *N*	Clear	3	1.09
		14	16	α *Aquilæ* $0^{m}.4$ > *N*	In haze	1	1.29
		15	14 50	α *Cygni* − 4 − *N* − 6 − γ *Cygni*	In haze	1	1.73

Date	G. M. T	Observations by H. L. A.	Sky	Wt.	Magn.
	h m				
1918 June 8	17 0	α *Lyræ* – 4 – *N* – 4 – α *Aquilæ*	Clear	.	0.52
	19 0	α *Lyræ* – 3 – *N* – 5 – α *Aquilæ*	Clear	.	0.42
9	18 0	*N* – 10 – α *Lyræ* – 8 – α *Aquilæ*	Clear	.	−0.80
	21 0	*N* – 13 – α *Lyræ* – 8 – α *Aquilæ*	Clear	.	−1.08
15	18 0	α *Lyræ* – 8 – α *Aquilæ* – 8 – *N* – 3 – α *Coronæ* – 1 – α *Oph.*	......	.	1.84
	....	*N* $0^m.3$ > α *Ursæ Minoris*	......	.	.....
19	18 0	γ *Cygni* – 1 – *N* – 1 – ε *Cygni*	Clear	3	2.41
	..	α *Oph.* $0^m.2$ > *N*	......	.	2.34
22	18 0	α *Oph.* – 6 – *N* – 2 – β *Oph.*	Clear	3	2.74
23	15 0	β *Oph.* $\overline{>}$ *N*	.....	.	2.94
27	17 25	*N* 0.3 > θ *Serp.*	Clear	3	...
	...	λ *Aquilæ* – 3 – *N* – 3 – 12 *Aquilæ*	......	.	...
	...	δ *Aquilæ* 0.2 > *N*	.....	.	3.8
	..	β *Aquilæ* = *N*	......	.	....
	..	η *Serpentis* 5 > *N*	.....	.	..
July 1	14 30	γ *Aquilæ* – 3 – *N* – 1 – η *Serp.* – 1 – λ *Aquilæ*	Clear	3	3.3
2	15 30	γ *Aquilæ* – 4 – *N* – 1 – η *Serp.* – 1 – λ *Aquilæ*	.....	.	3.3
3	....	γ *Aquilæ* – 3 – *N* – 3 – η *Serp.*	.....		3.1
	...	β *Oph.* – 2 – *N* – 2 – η *Serp.*	.....		3.2
8	15 0	η *Serp.* – 2 – *N* – 3 – β *Aquilæ* – 2 – θ *Serp.*	Clouds	?	3.6
13	16 0	3.8	Clear	3	3.8
14	16 0	β *Aquilæ* = *N*	.....	.	3.9
27	16 0	3.9	....	.	3.9
28	16 0	4.0	...	.	4.0
Aug. 2	16 0	4.3	...	.	4.3
3	16 0	4.3	..	.	4.3
5	16 0	4.3	.	.	4.3
6	15 0	η *Serp.* = 36 – 2 – δ *Aquilæ* – 3 – *N* – 2 – θ *Serp.*	.		3.9
11	18 0	η *Serp.* = *N*	.		3.4
13	17 0	θ *Serp.* – 4 – *N* – 5 – 4 *Aquilæ*		.	4.5

Leander McCormick Observatory,
University of Virginia,
1919, June 18

VARIABLE STARS IN THE CLUSTER *M 11* (*N. G. C.* 6705),

By E. E. BARNARD.

I have found one variable star, and probably another, in the cluster *M 11*. They are in the northern part of the cluster, in the positions

1	1900.0	α $18^h\,45^m\,47^s.58$	δ $-6^\circ\,15'\,22''.2$
2		18 45 38 .27	−6 19 47 .7

No. 1 is shown as a 14th magnitude star on two plates of mine with the 10-inch telescope, apparently at or near maximum. It is absent on a number of other plates.

No. 2 is only shown on one plate, but I feel sure the image is that of a real star. It is about 13½ magnitude.

Professor Bailey verifies No. 1 on the H. C. O. photographs, but does not find No. 2 on any of the five plates available for comparison.

At the present time No. 1, which is visible in the 40-inch telescope, is brightening. They are both perhaps of long period and wide range of magnitude.

Yerkes Observatory,
Williams Bay, Wisconsin.
August 11, 1919.

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

By E. E. BARNARD.

These observations are a continuation of those printed in *Astronomical Journal* No. 720 (XXX, 214, 1917) and previous numbers. The observations are in Central Standard Time, $6^h 0^m$ slow of Greenwich Mean Time.

Neptune AND ITS SATELLITE

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1917 Nov. 10	16 33 47	29.52	.	6
	16 40 24	. . .	10.11	9
Dec. 5	15 27 54	302.30	.	5
	15 35 52	.	16.54	12
6	13 37 39	260.19		7
	13 47 12	. . .	12.42	15
8	15 4 40	109.29	. .	5
	15 11 51	. .	16.75	10
15	14 56 3	61.44		5
	15 3 57	. . . .	11.22	10
25	10 31 20	154.02		6
	10 37 46	. .	13.61	11
1918 Jan. 8	11 48 12	26.18		6
	11 55 10	. . . . .	10.66	11
19	11 37 18	88.58	.	6
	11 46 4	. . . .	13.84	10
29	11 13 52	167.17	. . .	6
	11 20 26	. . .	12.20	10
31	13 34 10	65.97		8
	13 40 31	. . .	11.80	10
Feb. 16	9 50 47	153.52		8
	9 59 26	. . .	14.86	10
23	10 24 5	103.75	.	6
	10 30 29	. . . .	15.48	10
28	13 8 45	134.17	. . . .	6
	13 14 3	. . . . .	16.45	9
Mar. 2	11 33 16	17.71	. . . .	5
	11 38 8	. . . .	10.43	8
1918 Mar. 7	13 11 15	85.58	. . . .	5
	13 16 20	. . . .	13.86	10
16	10 39 55	258.20	. . . .	5
	10 11 29	. . .	12.72	8
19	11 26 28	76.72	. . . .	7
	11 32 38	. . .	12.80	8
23	9 18 59	169.34	. . . .	6
	9 24 1	. . . .	12.22	8
26	9 11 1	346.22	. . . .	6
	9 17 9	. . . . .	12.18	8
30	10 20 0	113.70	. . . .	6
	10 24 26	. . . .	17.08	8
Apr. 4	11 29 45	148.04	. . . .	5
	11 35 19	. . .	14.33	8
13	9 2 19	325.27		5*
	9 6 54	. . . . .	14.44	9
23	8 25 28	97.69	. . .	5
	8 29 16	. .	14.72	8
Nov. 26	13 56 43	107.36	. . . .	5
	14 0 43	. . . .	15.48	8
30	13 48 29	202.86	. .	5
	13 53 24	. . . . .	10.04	8
Dec. 5	13 40 33	279.79	. . .	6
	13 45 57	. . . .	14.20	8
7	13 8 35	137.39	. . . .	5
	13 14 15	. . .	15.94	8
1919 Jan. 18	9 55 33	108.71	. . . .	6
	10 2 20	. . . . .	16.19	8
21	13 15 15	137.81	.	5
	13 23 28	. .	16.20	7

*Satellite 12½ magnitude.

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1919 Jan. 28	13 56 43	189.93	....	5
	14 0 32	...	11.33	8
30	13 30 22	91.28	..	5
	13 35 14	....	13.80	10
Feb. 1	8 36 3	318.57	..	5‡
	8 43 5	.....	15.99	10
4	9 41 42	132.31	...	5
	9 48 40	...	16.76	10
6	12 27 54	359.70	..	5
	12 34 14	....	11.31	10
11	12 6 51	79.46	..	5
	12 14 6	...	12.74	10
15	8 53 10	175.54		6
	9 0 4	.	11.70	10
18	11 12 37	345.82	.	5
	11 18 4	..	12.65	10
25	10 2 44	296.98	...	5
	10 8 8	....	16.99	8
Mar. 1	10 3 19	57.24	..	5
	10 9 46	...	11.12	8
6	10 26 41	109.71	..	5
	10 32 10	....	16.26	10

‡Satellite 13 magnitude. Well seen.

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1919 Mar. 11	10 20 39	145.02	...	5
	10 26 9	....	15.49	10
18	9 35 33	100.41	...	5
	9 40 18	....	15.19	8
22	8 34 40	201.16	..	5
	8 40 30	.....	10.23	10
27	10 43 0	266.88	...	5
	10 47 22	.....	13.28	8
Apr. 1	8 27 31	311.23	...	5
	8 31 54	...	16.44	8
12	10 24 41	342.20	..	6
	10 29 24	...	12.91	8
22	7 56 23	114.67	.	5
	8 1 12	...	16.13	8

Neptune and a Star North ($12\frac{1}{2}^M$ or 13^M)

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1918 Mar. 16	10 50 44	31.66	...	4
	10 55 14	....	19.12	8

Neptune and a Star North Prec. (10^M)

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1919 Mar. 22	8 46 12	327.07	....	4
	8 50 52	..	51.88	8

Yerkes Observatory,
Williams Bay, Wisconsin.
June 20, 1919.

DISCOVERY AND ELEMENTS OF COMETS 1919 *b* AND 1919 *c* (Metcalf).

A comet was discovered by the Rev. Joel H. Metcalf on August 20, and on August 22 he discovered a second comet. Below are given the elements of the two comets computed by Mr. Jeffers and Miss Heger.

(T) 1919, Oct. 16.33 G.M.T.	(T) 1919, Dec. 18.91 G. M. T.
(ω) 127° 51′	(ω) 173° 7′
(Ω) 311° 41′	(Ω) 108° 55′
(ι) 20° 15′	(ι) 47° 34′
(q) 0.487	(q) 1.594

Professor A. O. Leuschner states:—"According to elements by Jeffers and Heger first Metcalf comet identical 1847 V."

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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THE

ASTRONOMICAL JOURNAL

FOUNDED BY B. A. GOULD

No. 758

VOL. XXXII ALBANY, N.Y., 1919, OCTOBER 24 NO. 14

OBSERVATIONS OF THE SATELLITES OF *URANUS*,

By E. E. BARNARD.

The following observations are a continuation of those printed in *Astronomical Journal* No. 699 (30, 20, 1916) and in previous numbers. They are in Central Standard Time, 6^h 0^m slow of Greenwich Mean Time.

Date	C. S. T.	P. A.	Dist.	Cps.
	Uranus AND *Ariel*			
	h m s	°	″	
1916 Aug. 19	9 59 22	351.93	. . .	6
	10 7 44	. . . . .	14.49	4
	10 56 43	352.70	. . . .	5
	11 5 27	. . . . .	13.68	9
Oct. 10	8 0 35	188.12	. .	5*
	8 9 43	. . . . .	11.95	12
	Uranus AND *Umbriel*			
1916 Aug. 19	11 14 43	334.50	. . . .	7
	11 22 10	. . . . .	16.21	4
	Uranus AND *Titania*			
1916 June 24	14 35 58	172.79	. . . .	5
	14 41 58	. . . . .	31.30	8
July 5	14 25 36	284.20	. . . .	5
	14 31 0	. . . .	15.37	8
29	13 3 59	175.42	. . . .	5
	13 12 36	. . . .	31.08	8
Aug. 2	11 55 48	349.23	. . . .	5
	12 0 49	. . . .	31.72	10
16	11 57 29	189.56	. . .	5
	12 3 42	. . . .	28.22	9

*Ariel = 16th magnitude.

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1916 Aug. 19	10 17 23	338.62	. .	5
	10 23 52	. . . .	29.55	10
23	10 59 18	149.75	. . . .	5
	11 5 25	. . . . .	26.52	10
30	10 42 28	46.25	. . . .	6
	10 51 29	. . . .	18.70	10
Sept. 2	10 41 29	178.73	. . . .	5*
	10 47 19	. . . . .	31.38	10
13	11 19 39	298.92	.	5
	11 32 22	. . .	18.18	3
18	9 44 28	144.29	. . . .	5
	9 49 32	. .	24.69	8
22	9 6 55	309.19	. . . .	5
	9 11 50	. . . .	20.32	8
Oct. 1	8 12 17	320.87	. . . .	6
	8 20 19	. . . . .	24.93	2
3	8 6 10	10.83	. . . .	5
	8 13 14	. . . . .	28.32	10
10	8 17 59	329.69	. . . .	5
	8 24 2	. . . . .	25.67	10
15	7 11 41	164.61	. .	5
	7 19 23	. . . .	30.71	10
21	7 13 16	28.32	. . . .	5
	7 18 46	. . . . .	22.03	10

*Oberon 8-10 or 1 magnitude brighter than *Titania*.

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1916 Oct. 31	6 46 17	111.95	...	5
	6 54 24	.....	17.24	11
1918 July 18	13 53 4	7.90	.	4
	13 57 1	..	23.25	8
Oct. 12	8 32 42	346.90	....	5
	8 37 40	.....	30.62	8

Uranus AND *Oberon*

Date	C. S. T.	P. A.	Dist.	Cps.
1916 June 24	14 24 35	328.85	..	5
	14 29 38	.....	33.66	8
July 5	14 15 22	225.77	....	5
	14 20 25	.....	22.53	8
8	13 58 23	337.72	...	5*
22	13 55 3	345.07	...	5
	14 1 32	.....	41.27	10
29	13 22 24	166.90	....	5
	13 29 38	....	43.11	4
Aug. 2	12 6 23	278.59	...	5
	12 11 15	.....	20.81	9
16	12 10 21	302.62	....	5
	12 21 6	.....	24.59	13
				6
19	10 31 29	356.93	....	
	10 38 27	.....	42.06	10
23	11 11 2	129.71	....	4
	11 17 0	.....	26.95	9
26	10 51 44	180.21	...	5
	11 1 8	....	40.75	8
30	10 22 34	315.92	....	6
	10 31 21	.....	29.87	10
Sept. 2	10 24 41	4.61	...	5
	10 31 21	....	39.35	10
18	9 54 35	85.65	....	5
	10 1 1	...	21.20	8
22	8 53 14	181.50	..	5
	9 1 8	.....	40.84	8

*Observation stopped by clouds.

Date	C. S. T.	P. A.	Dist.	Cps.
	h m s	°	″	
1916 Oct. 3	7 50 49	126.46	....	6
	7 59 7	..	22.26	11
10	8 30 40	328.19	...	5
	8 38 13	.....	34.02	12
15	7 28 1	84.00	..	5
	7 34 23	..	21.36	10
21	7 0 48	228.15	..	5
	7 6 45	....	23.19	10
31	6 32 56	160.38	...	5
	6 38 6	...	38.67	10
1917 Aug. 18	12 0 56	2.32	....	5
	12 6 21	.....	39.09	8
1918 Aug. 1	12 54 1	340.29	....	5*
27	11 16 14	323.90	....	5
	11 21 45	.....	28.14	8
Nov. 5	7 14 25	354.49	...	5
	7 20 34	....	38.81	9

Uranus AND A 12TH MAG. STAR

Date	C. S. T.	P. A.	Dist.	Cps.
1916 Aug. 2	11 43 17	6.93	...	5
	11 48 23	....	30.23	8

Uranus AND A 14TH MAG. STAR

Date	C. S. T.	P. A.	Dist.	Cps.
1916 Oct. 10	7 44 44	306.20	....	6
	7 52 10	....	6.38	10

Uranus AND A 6½ MAG. STAR

Date	C. S. T.	P. A.	Dist.	Cps.
1918 July 25	13 44 1	160.24	..	5
	13 50 39	.....	221.06	8

Titania AND *Ariel*

Date	C. S. T.	P. A.	Dist.	Cps.
1916 Sept. 2	11 17 8	354.51		5
	11 23 42	....	17.70	10

Titania AND *Oberon*

Date	C. S. T.	P. A.	Dist.	Cps.
1916 Sept. 18	9 28 5	23.47		7
	9 33 44	.....	22.51	9
Oct. 15	8 1 19	21.65	...	5
	8 7 20	....	33.52	10

*? if *Oberon*. Observation stopped by clouds.

Date	C. S. T.	P. A.	Dist.	Cps.
Titania AND A VERY FAINT STAR SOUTH				
	h m s	°	″	
1916 Sept. 2	11 4 23	177.68	....	3*
	11 9 57	...	15.48	6
Titania AND A SMALL OBJECT PREC. (15^{M}, FOL. OF 2)				
1916 Oct. 21	7 32 5	225.30	...	5
	7 38 15	..	8.86	10

*Measures exceedingly difficult.

Date	C. S. T.	P. A.	Dist	Cps.
Oberon AND A 15TH MAG. STAR SOUTH				
	h m s	°	″	
1916 Oct. 3	8 20 7	177.49	....	5
	8 26 28	....	11.94	10

Yerkes Observatory,
Williams Bay, Wisconsin.
June 20, 1919.

NOTE.

The undersigned, astronomer at the Leyden Observatory, is about to undertake a reduction of the old *Paramatta Catalogue* for 1825. A notice of DR. POWALHY, dated 1878 I believe, states that after the death of RUMKER in 1861 the observations made at Paramatta from 1826—1828, containing some 7000 starplaces, have been put in his hands for publication. Apparently DR. POWALHY took no further action and I see, in *Astronomische Nachrichten* Vol. 100, that he died at Washington in 1881. Perhaps some of your readers will know where those unpublished and very important observations went, and if so would communicate with me regarding this matter.

J. E. DE VOS VAN STEENWIJK.

Oegstgeest near Leyden,
June 17, 1919.

OBSERVATIONS OF BORELLY'S PERIODIC COMET,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy Superintendent.]

Date	Wash. M.T.	✳	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log $p\Delta$		Red. of ✳ to App. Pl.		See'g	Obs.
1918	h m s			m s	′ ″	h m s	° ′ ″			s	″		
Oct. 23	13 14 42	1	d 8, 8	+0 9.40	+0 37.4	6 18 35.97	− 2 39 24.5	9.503n	0.758	+3.97	+ 4.0	f	Bn
Nov. 1	13 38 27	2	t 30, 6	+1 35.27	+1 21.5	6 32 28.38	+ 1 54 16.7	9.394n	0.725	+4.27	+ 0.6	p	Bn
8	12 53 19	3	t 20, 4	+1 22.99	−0 7.6	6 41 52.30	+ 6 26 17.2	9.467n	0.688	+4.56	− 2.6	f	Bn
25	12 30 46	4	t 25, 5	+4 17.45	+3 15.6	6 58 20.84	+21 46 53.2	9.423n	0.472	+5.47	− 9.6	p	B
25	16 5 22	5	d 12, 10	+0 4.69	+0 53.4	6 58 25.57	+21 56 22.9	9.251	0.433	+5.46	−10.2	p	B
Dec. 17	9 54 41	6	d 12, 12	−0 7.74	−2 19.7	6 59 33.64	+46 5 18.3	9.705n	9.819	+7.48	−14.2	p	B
18	10 17 17	7	d 12, 10	+0 23.73	+3 19.3	6 58 57.82	+47 5 41.4	9.665n	9.002	+7.61	−14.0	g	B
26	11 23 47	8	d 12, 10	−0 26.80	−4 15.8	6 52 19.20	+54 8 28.9	9.365n	0.319n	+8.65	−12.2	f	B
1919 Jan. 6	10 11 48	9	t 30, 6	−3 40.18	−7 56.3	6 40 6.43	+60 49 59.7	9.535n	0.461n	+4.66	− 4.5	g	B
9	10 15 38	10	t 50, 10	−1 39.92	+1 47.5	6 36 18.98	+62 6 42.5	9.448n	0.509n	+4.81	− 3.3	p	B
11	9 5 58	11	d 12, 10	−1 23.12	−2 37.7	6 34 50.39	+62 49 39.7	9.721n	0.128n	+4.94	− 2.6	g	B
18	8 52 8	12	d 12, 13	−1 12.87	−3 32.7	6 29 15.52	+64 44 37.0	9.685n	0.503n	+5.29	− 0.2	f	B
20	9 2 4	13	d 12, 10	+0 2.03	+2 50.2	6 28 12.93	+65 7 41.0	9.612n	0.538n	+5.30	+ 0.6	f	B
Feb. 6	7 55 52	14	d 12, 10	+0 40.71	+0 27.1	6 32 2.49	+66 14 25.3	9.646n	0.552n	+5.25	+ 4.1	g	B
24	8 9 57	15	t 50, 10	−1 45.13	+2 59.0	6 57 55.77	+64 46 53.5	9.181n	0.579n	+4.73	+ 4.4	g	B
26	7 48 20	16	d 12, 10	+0 37.73	+1 2.3	7 1 11.01	+64 30 50.1	9.362n	0.565n	+4.66	+ 4.5	f	B
Mar. 21	8 54 11	17	d 12, 10	+0 18.74	−0 13.1	7 50 58.27	+60 21 40.0	9.360	0.485n	+3.76	+ 2.9	p	B
Apr. 21	10 9 51	18	d 12, 10	+0 12.27	−3 1.6	8 58 29.06	+52 52 59.6	9.743	9.615n	+2.80	− 0.1	f	B

Under comparisons, d signifies direct measurement, driving clock running; t, measures made by transits.
Seeing: g = good, f = fair, p = poor.
Observers: Bn = H. E. BURTON, B = ERNEST CLARE BOWER.

Mean Places of Comparison Stars for the Beginning of the Year.

*	α	δ	Authority
	h m s	° ′ ″	
1	6 18 22.60	− 2 40 5.9	*A. G. Straszburg* 2061
2	6 30 48.84	+ 1 52 54.6	*A. G. Albany* 2272
3	6 40 24.75	+ 6 26 27.4	*A. G. Leipzig II* 3188
4	6 53 57.92	+21 43 47.2	*A. G. Berlin B.* 2706
5	6 58 15.42	+21 55 39.7	⅓ { Astr Par +23°.07h 00m, 620 (10.4); Astr Par +22 .06 56 , 650 (10.6); Astr Par +21 .07 00 , 28 (10.6) }
6	6 59 33.90	+46 7 52.2	*A. G. Bonn* 5728
7	6 58 26.48	+47 2 36.1	Star ($9^m.5 - 10^m.0$) comp. with *A. G. Bonn* 5711 1918.0: $\Delta\alpha = +0^m\ 32^s.25$, $\Delta\delta = -7'\ 34''.1$, 1918 Dec. 26
8	6 52 37.35	+54 12 56.9	*A. G. Cambridge, U. S.* 2680
9	6 43 41.95	+60 58 0.5	*A. G. Hels-Gotha* 4732
10	6 38 24.09	+62 4 58.3	*A. G. Hels-Gotha* 4687
11	6 36 8.57	+62 52 20.0	*A. G. Hels-Gotha* 4652
12	6 30 23.10	+64 48 9.9	*A. G.* ½ { *Christiania* 1062; *Hels-Gotha* 4594 }
13	6 28 5.60	+65 4 50.2	*Astr Grn* +65° .06h 27m, 2179
14	6 31 16.53	+66 13 54.1	*A. G. Christiania* 1063
15	6 59 36.17	+64 43 50.1	*A. G. Hels-Gotha* 4878
16	7 0 58.62	+64 29 43.3	*A. G. Hels-Gotha* 4892
17	7 50 35.77	+60 21 50.2	*A. G. Hels-Gotha* 5292
18	8 58 13.99	+52 56 1.3	Star ($12^m.0\pm$) comp. with *A. G. Camb., U. S.* 3270 1919.0: $\Delta\alpha = +2^m\ 58^s.64$, $\Delta\delta = -3'\ 45''.6$, 1919 Apr. 21

NOTES

Oct. 23. Moonlight and haze. Comet nebulous.
Nov. 1. Comet visible in 5-inch finder. Nucleus fairly well defined.
8. Haze. Comet faint at times.
25. Nucleus $10^m.5$. Head about 6″ in diameter.
Dec. 17. Bright moonlight $11^m.0\pm$.
18. Bright moonlight.
26. $10^m.0\pm$
Jan. 6. Transits of comet rather poor.
9. Windy. Poor transits of comet.
11. Moonlight.
Feb. 6. $12^m.5\pm$
24. $13^m.0$. Transits of comet very poor. Faint wires fluctuated very much in brightness.
26. $13^m.0$. Faint wires fluctuated very much in brightness.
Mar. 21. $13^m.5$. Poor observation.
Apr. 21. $14^m.0\pm$. Poor observation.

Washington, D. C., July 23, 1919.

NOTE ON TWO RAPIDLY MOVING STARS IN *PISCES*,

BY FRANK SCHLESINGER.

In the Publications of the Astronomical Society of the Pacific for December, 1917, DR. VAN MAANEN calls attention to a star of the twelfth magnitude that has an annual proper-motion of 3″.0. Its position for 1900 is

$$0^h\ 43^m\ 53^s \quad +4°\ 54'.4$$

This star is only 11′ distant from the sixth magnitude star *B. D.* +4° 123, which has an annual proper-motion of 1″.4, this proper-motion having been derived thirty years ago by the Albany observers. DR. MAX WOLF has recently made an independent discovery of the large motion of the faint star (*Astronomische Nachrichten* 4984). In spite of the large difference between the motions of the two stars, DR. WOLF expresses the belief that they form a physical system

and gives some particulars regarding their relative orbit on this assumption.

The brighter star of the two was placed on the Allegheny programme for a determination of its parallax in August, 1917; since then eight well-distributed plates have been obtained. The writer has measured these and derives for the relative parallax

$$+''.15 \quad \pm''.008$$

This agrees, as well as can be expected, with CHASE's determination, $+''.16 \quad \pm''.048$; and with FLINT's, from his second series, $+0''.18 \quad \pm''.040$.

The Allegheny plates also show the fainter star detected by VAN MAANEN and WOLF; its measurement yields the relative parallax

$$+0''.27 \quad \pm 0''.012$$

This confirms the large value derived by VAN MAANEN. (Publications of the Astronomical Society of the Pacific, February, 1919), $+0''.244 \quad \pm''.008$.

In view of the large difference in parallax that these results prove to exist, the assumption that the two stars form a physical system must be abandoned. Their close proximity on the celestial sphere is a remarkable coincidence, but nothing more.

The two parallaxes from the Allegheny plates quoted above should be regarded as preliminary only. They will be superseded by definitive values after our set of plates has been completed.

Allegheny Observatory,
University of Pittsburgh,
June 2, 1919.

MEASURES AND APPROXIMATE ORBIT OF γ *LUPI*.

By BERNHARD H. DAWSON.

Historical. γ *Lupi* was discovered to be double by SIR JOHN HERSCHEL at the Cape of Good Hope in 1834, being at that time a moderately difficult pair of something less than 1″ separation. He observed it many times in position angle, but only made two measures of distance, the rest of his distances being estimates. It was observed by CAPT. JACOB in India in 1853 and again in 1856. Since that time the star has been one of considerable difficulty, and from 1857 to 1897 or later it was not seen separated, although elongation or possible elongation was noted several times at Sydney and Melbourne.

In 1897 PROF. SEE measured this pair with the Lowell refractor, and in *Monthly Notices*, vol. LVIII, p. 15, with the scanty evidence then at hand, concluded that it was a binary with inclination nearly 90°, and that it had twice passed occultation between 1857 and 1897 and was again opening out to the position in which HERSCHEL observed it.

After measures in 1900–02 with the Cape 18-inch, MR. INNES suggested a uniform decrease in distance from HERSCHEL's time till then. This supposes, not only that INNES' own distances are too large, but also that HERSCHEL's distances are much too small; in effect, that they are *all* estimates and subject to the well-known systematic correction.

Since that time the pair has been re-observed by INNES with the Johannesburg 9-inch, but at first for lack of micrometer and later on account of excessive closeness, his distances are all estimates. It has also been observed by the writer with the La Plata 17-inch, and though at no time was the pair seen divided, yet the measures of elongation are considered fairly trustworthy. Of these results those of 1919 are heretofore unpublished. All are with magnification 1125.

1900+	*P*	*S*	*θ*	Seeing
	°	″	h	
14.397	90.8	0.23	19.4	4
14.572	79.4	0.23	16.9	4
17.272	77.6	0.21	15.1	3
17.477	73.3	0.2 ±	16.7	3½
17.608	80.5	0.15	17.9	3
19.268	86.0	0.1 ±	13.4	2½
19.325	78.4	<0.10	12.4	4

With these new data the problem, which has long been an enigma among the southern doubles, at last becomes qualitatively soluble, and a fair approximation to the numerical values may be obtained. Such a solution is the purpose of the present paper.

Qualitative deductions. Collecting all the observations, we obtain the following table:

Date	*P*	*S*	*n.*	Aperture	Observer
	°	″			
1835.05	94.3	—	9	6*in*	HERSCHEL.
1835.24	–	0.84	2	6	HERSCHEL.
1836.52	95.5	$\frac{2}{3}$	1	18	HERSCHEL.
1837.04	93.8	-	6	6	HERSCHEL.
1853.1	273.4	1.03	2	–	JACOB.
1856.17	275.4	$\frac{3}{4}$	3	–	JACOB.

Date	P	S	n.	Aperture	Observer
1871.46	Single.		1	7	RUSSELL.
1877.4	Plainly elong.		1	–	MELBOURNE.
1877.50	270 ±	E.	1	11	RUSSELL.
1877.54	Single.		3	11	RUSSELL.
1880.58	270 ±	E?	1	11	RUSSELL.
1880.67	Single.		1	7	HARGRAVE.
1881.54	Single.		1	11	RUSSELL.
1886.57	90 ±	E?	1	11	RUSSELL.
1886.57	Single.		1	7	POLLOCK.
1887.53	Triangular.		1	11	POLLOCK.
1895.56	Single.		3	11	SELLORS.
1896	Single.		2	-	INNES.
1897.07	91.7	0.38	3	24	LOWELL OBS.
1898	Divided.		–	18	INNES.
1900.61	91.5	0.36	4,2	18	INNES.
1902.10	90.0	0.70	3	18	INNES.
1909.6	80 ±	0.5 ±	–	9	INNES.
1910.6	80 ±	0.5 ±	–	9	INNES.
1913.48	90 ±	E.	2	9	INNES.
1914.48	85.1	0.23	2	17	DAWSON.
1914.54	262 ±	E.	2	9	INNES.
1917.45	77.1	0.19	3	17	DAWSON.
1919.30	82.2	$\leq$0.10	2	17	DAWSON.

From this table we may immediately conclude that the star is a binary, and, since the angles are nearly constant, that the inclination is nearly 90°. This agrees with SEE's first conclusion. We can also see that the distance was increasing in 1897, which also agrees with part of SEE's second conclusion, and renders untenable INNES' supposition of uniformly decreasing distance. But the new data show that the pair is again closing up, and that at no time since 1890 has the distance been as great as those observed by HERSCHEL and JACOB. This makes it clear that the portion of the orbit described by the companion since 1890 does not contain the position in which it was observed by them, and does contain periastron. Hence there was but one occultation between 1860 and 1900, the epoch being near 1890 while the epoch of the second occultation can be fixed as 1920 very nearly.

The quadrant during the interval since 1890 must consequently be the opposite of that before that time, and as the majority of the observations indicate that the smaller star (if there be any difference of brightness) has recently been in the following quadrant, this is adopted. As the inclination is very nearly 90 the observations of position angle will determine node and inclination, but will leave the other elements to be determined from the distances alone. If we now plot the distances as function of the time, considering those before 1890 as negative, and seek by trial a set of values for the other elements which shall give a similar curve, we shall be led to the following conclusions:

A negative value of ω conflicts with the slow decrease in distance before 1890, while a positive value conflicts with the rapid apparent increase after that date, and $\omega = 0$ is a satisfactory compromise. This will bring T about 1905.

Supposing $\omega = 0$, the maximum separations on each side give us $a\,(1+e)$ and $a\,(1-e)$ directly, the latter being on the order of 0″.5, perhaps slightly more. If we disregard HERSCHEL's distance, P and $a\,(1+e)$ are indeterminate and may both be large. If we consider it exact, $a\,(1+e)$ must be on the order of 1″.0 and P slightly over 100 years. By varying P, a and e together it is possible to obtain various sets of elements which give very similar curves for the interval since 1875, and as the curve will be symmetrical about the epoch of periastron, we see that observations during the next ten years or so will help us but little towards a more accurate determination of these doubtful elements.

In view of this last deduction and of the peculiar interest of the problem it was thought advisable to derive the best approximation possible from the data now at hand, in spite of the fact that their paucity hardly justifies a least squares solution.

*Quantitative solution.**) As a point of departure the following trial elements were used.

$$\begin{aligned} P &= 120 \text{ years},\\ T &= 1905.0,\\ e &= 0.40,\\ a &= 0''.80,\\ \omega &= 0. \end{aligned}$$

Selecting the *measured* distances and combining the negative observations of 1887 and 1895 into one of distance zero, the following comparison was obtained.

Date	ρ_o	ρ_c	$O-C$
	″	″	″
1835.24	−0.84	−1.07	+0.23
1853.10	−1.03	−1.09	+0.06
1891.54	0.00	+0.08	−0.08
1897.07	+0.38	+0.32	+0.06
1900.61	+0.36	+0.43	−0.07
1902.10	+0.70	+0.45	+0.25
1914.48	+0.23	+0.26	−0.03
1917.45	+0.19	+0.12	+0.07
1919.30	+0.08	+0.04	+0.04, [nn] = 0.1413.

*SCHLESINGER's *Tables for the True Anomaly in Elliptic Orbit* and a 20-inch slide rule were used throughout the work.

Since $i = 90°$, the formulae given by PROF. COMSTOCK in *Astronomical Journal*, No. 725 are unmanageable, as all his distance coefficients except h contain $\tan i$ and become infinite. But we may differentiate the equation.

$$\rho = r \cos u,$$

obtaining, after some reductions,

$$d\rho = \frac{\rho}{a}\, da - r \sin u\, d\omega - \left(\frac{r \sin u \sin v}{1-e^2} + a \cos \omega\right) de$$
$$+ \frac{a\,(\sin u + e \sin \omega)}{\sqrt{1-e^2}}\,(\mu\, dT + (T-t)\, d\mu).$$

But since we have $\omega = 0$, we may simplify this with the relations

$$\sin \omega = 0, \quad \cos \omega = 1, \quad u = v,$$

obtaining for our special case

$$d\rho = \frac{\rho}{a}\, da - r \sin v\, d\omega - \left(\frac{r \sin^2 v}{1-e^2} + a\right) de$$
$$+ \frac{a \sin v}{\sqrt{1-e^2}}\,(\mu\, dT + (T-t)\, d\,\mu),$$

$$\frac{\partial\rho}{\partial a} = \frac{\rho}{a}, \qquad \frac{\partial\rho}{\partial\omega} = -r \sin v, \qquad \frac{\partial\rho}{\partial T} = \frac{\mu\, a \sin v}{\sqrt{1-e^2}},$$

$$\frac{\partial\rho}{\partial e} = -\frac{r \sin^2 v}{1-e^2} - a, \qquad \frac{\partial\rho}{\partial\mu} = \frac{(T-t)\, a \sin v}{\sqrt{1-e^2}};$$

in which all angles are supposed expressed in radian measure.

The equations of condition were formed with the residuals found above and these partial differential coefficients computed for the corresponding dates. In a first solution for the increments to the elements it became evident that ω and T were not separately determinate. To obviate this difficulty T was assumed to be a linear function of ω, such that their combined variation should leave unchanged the epochs of occultation. This gives us the relation $\Delta T = 14.2\, \Delta\omega$, by means of which we may combine their coefficients. To facilitate the numerical work the quantities actually used as unknowns were:

$$x = \Delta a, \quad y = 2\Delta e, \quad z = 15\Delta\mu, \quad w = \frac{\Delta\omega}{5} = \frac{\Delta T}{71};$$

obtaining the following system of normal equations:

$$\begin{aligned}
+4.552\, x - 0''.032\, y - 1''.494\, z - 0''.831\, w &= -0''.259 \\
-0.032\, x + 3\ .445\, y + 2\ .996\, z - 0\ .085\, w &= -0\ .243 \\
-1.494\, x + 2\ .996\, y + 6\ .103\, z - 1\ .568\, w &= +0\ .206 \\
-0.831\, x - 0\ .085\, y - 1\ .568\, z + 7\ .858\, w &= -0\ .076
\end{aligned}$$

from which were derived:

$x = -0''.0194$	$\Delta a = -0''.019$	$a = 0''.78$
$y = -0\ .1712$	$\Delta e = -0\ .086$	$e = 0\ .314$
$z = +0\ .1170$	$\Delta\mu = +0°.45$	$P = 104\ .3$ years
$w = +0\ .0101$	$\Delta\omega = +0°.050$	$\omega = +2°.9$
	$\Delta T = +0\ .72$	$T = 1905.7$

For a determination of the position of the orbit plane we have directly from geometrical considerations,

$$s \sin (P - \Omega) = r \sin u \cos i.$$

Since in our case the angle $P - \Omega$ is small, and i very near 90°, we may write without appreciable error,

$$a(P - \Omega) = r \sin u\, (90° - i),$$

or,

$$sP = s\Omega - r \sin u\, \Delta i.$$

But since in general the accuracy of sP increases and that of P decreases with diminishing separation, a better weighting may be obtained by the compromise

$$\sqrt{s}\, P = \sqrt{s}\, \Omega - \frac{r}{\sqrt{s}} \sin u\, \Delta i.$$

As these coefficients are homogeneous, we may express the angles in degrees, and since the observations of position angle are much more numerous than those of distance we may omit the least squares solution and add all the observation equations in which the coefficients of the unknowns have like signs for one normal equation and those with unlike signs for the other, after correcting the observed position angles for the effect of precession. In this way were found:

$$1891.4 = 20.350\,\Omega + 14.565\,\Delta i$$
$$801.3 = 9.038\,\Omega - 13.612\,\Delta i$$
$$\Omega = 91^\circ.56\ (1900) - 91^\circ.5\ (1910)$$
$$\Delta i = +\,1^\circ.93, \quad i = 91^\circ.9$$

Combining these results we have as probably the best system of elements obtainable with the present data:

$$P = 104.3 \text{ years}$$
$$T = 1905.7$$
$$e = 0.314$$
$$a = 0''.78,$$
$$\omega = 2^\circ.9$$
$$i = \pm 91^\circ.9$$
$$\Omega = 91.5 \quad (1910)$$

corresponding to the apparent ellipse:

Major Axis	= 1″.56
Minor Axis	= 0 .05
Star from Centre	= 0 .24
Position of Major Axis	= 91°.5
Position of Periastron	= 91 .5

These elements give us the following comparison with the measures. (The estimates, except those nearest 1890, are omitted.)

Date	P_c	O - C	S_c	O - C	Obs.
	°	°	″	″	
1835.05	273.3	+1.0	0.77		h.
1835.24	273.2	. . .	0.78	+0.06	h.
1836.52	273.1	+2.4	0.82	. . . .	h.
1837.04	273.1	+0.5	0.83	. . . .	h.
1853.1	271.8	+1.6	1.03	0.00	J.
1856.17	271.6	+3.8	1.02	. . .	J.
1887.53	253.9	. . .	0.08	.	Pk.
1895.56	95.0	. . .	0.30	. . . .	Sel.
1897.07	94.1	−2.4	0.36	+0.02	λ
1900.61	92.8	−1.3	0.48	−0.12	I.
1902.10	92.3	−2.3	0.51	+0.19	I.
1914.48	88.2	−3.1	0.31	−0.08	δ
1914.54	88.2	−6 ±	0.30	. . .	I.
1917.45	84.3	−7.2	0.17	+0.02	δ
1919.30	75.1	+7.1	0.08	0.0	δ

$[vv] = 0.0734$

The following ephemeris shows that this pair will remain exceedingly difficult for several years, but should be fairly easy after 1930.

	P	S
	°	″
1919.7	69.8	0.06
20.7	15.8	0.02
21.7	299.7	0.05
22.7	286.6	0.09
23.7	281.0	0.14
26.7	276.2	0.29
29.7	274.6	0.42
32.7	273.7	0.55
35.7	273.2	0.66

In conclusion it may well be noted that while these elements were determined by differential corrections and agree well with the observations, they must nevertheless be considered as only approximate, for there are but two sets of distance measures before 1897, and we have seen that if we disregard one of these, the period, eccentricity and mean distance may all vary greatly. Nor can we be really certain of these elements until the companion has passed apastron. Yet in spite of this the above ephemeris should represent the apparent motion fairly well.

La Plata, 1919, June 19.

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OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL, Professor of Mathematics, U. S. Navy, and H. E. BURTON, Assistant in the Observatory.

[Communicated by Rear Admiral J. A. Hoogewerff, U. S. Navy, Superintendent.]

Date	W. M. T.	p	W. M. T.	s	Comp.	See'g	Obs.	Remarks
1912	h m s	°	h m s	″				
Dec. 9	13 6 21	311.740	13 8 27	16.01	4 , 5	4	HL	
	13 57 32	310.845	13 56 21	16.09	5 , 4	...	..	
13	12 44 12	89.326	12 42 11	15.24	4 , 4	2–3	HL	
	13 23 23	87.929	13 28 1	15.14	4 , 4	..	.	
19	13 1 21	83.534	12 55 38	14.72	4 , 4	3–4	HL	Haze and moonlight. Satellite v. faint.
	13 47 11	82.045	13 48 55	14.37	4 , 5	..		
28	11 45 0	253.933	11 45 54	13.90	4 , 4	3	HL	
	12 24 33	255.217	12 27 1	13.80	4 , 4	..	.	
	14 18 1	246.588	14 20 34	12.88	4 , 4	2–3		Moonlight. Satellite faint and diffi-
	15 5 41	245.144	15 3 57	13.27	4 , 4	..	.	cult.
30	12 15 43	118.216	12 17 27	16.72	4 , 4	3	HL	Satellite very faint.
	12 55 7	114.187	12 56 16	16.72	4 , 4	...	..	
1913 Jan. 1	10 33 44	349.479	10 28 58	12.15	4 , 4	2–3	HL	Mist and fog. Satellite faint.
	11 32 40	347.940	11 28 21	12.16	4 , 4	...	..	
8	11 49 14	287.646	11 50 22	17.26	4 , 4	3	HL	
	13 13 12	286.270	13 13 12	17.03	4 , 5	...		
9	13 46 48	229.721	13 52 56	11.51	4 , 4	2	HL	Delayed by clouds, and by short-
14	13 42 43	280.546	13 50 0	16.84	4 , 4	2	HL	circuit on instrument.
	14 20 56	277.980	14 21 2	16.65	4 , 4	.	.	
	14 54 35	276.232	14 58 1	16.56	4 , 4	.		Some haze.
	15 26 6	276.474	15 25 13	16.41	4 , 4	..	..	Satellite faint at last.
Feb. 4	11 25 50	86.757	11 26 32	15.16	4 , 4	3	HL	
	11 47 42	85.362	12 5 30	14.90	2 , 4	.	..	Stopped by clouds.
6	11 10 15	304.288	11 10 9	16.43	4 , 4	3–4	HL	
	11 43 12	303.276	11 43 12	16.54	4 , 4	...	.	
7	9 49 9	264.941	9 51 25	15.71	4 , 4	3–4	HL	
	10 26 55	264.269	10 28 55	15.30	4 , 4	...	..	
12	11 9 58	300.644	11 12 34	16.75	4 , 4	3–4	HL	Windy.
	11 44 43	297.223	11 44 9	16.61	4 , 4	...	..	
13	8 26 53	262.009	8 26 40	14.99	4 , 4	3–4	HL	Satellite faint on account of haze.
	9 12 36	261.187	9 12 54	14.80	4 , 5	...		
15	10 42 59	118.263	10 25 24	16.22	4 , 4	2–3	HL	Satellite very faint on account of moon-
	11 39 10	115.934	11 39 4	16.50	4 , 4	...	..	light and haze. Delayed by break in hand lamp wires.

Date	W. M. T.	p	W. M. T.	s	Comp's	See'g	Obs.	Remarks
1913	h m s	°	h m s	"				
Feb. 18	10 16 39	296.063	10 16 35	17.12	4 , 4	2–3	HL	Moonlight and haze. Satellite v. faint.
	10 56 25	294.426	10 58 36	17.15	4 , 5	. .	.	
25	9 59 36	243.687	9 59 51	13.37	4 , 4	2	HL	
	10 42 11	240.907	10 43 36	13.09	4 , 4	. .	. .	
28	7 57 41	66.499	7 59 7	13.66	4 , 4	3–4	BN	
	8 23 17	65.263	8 23 58	12.69	4 , 4	.		
	9 59 48	61.339	10 2 9	13.06	4 , 4	3		
	10 22 49	59.655	10 22 47	11.81	4 , 4	. .	.	
Mar. 5	10 59 40	191.958	11 1 10	16.37	4 , 4	3–4	BN	
	11 19 57	102.204	11 22 30	16.23	4 , 4	. . .	. .	Thin clouds when distance measures [were made.
6	10 3 18	51.113	10 4 8	11.52	4 , 4	3–4	BN	
	10 27 33	50.220	10 29 4	12.18	4 , 4	. . .	. .	
7	8 4 20	333.588	8 5 49	13.55	4 , 4	3	BN	
	8 34 13	331.611	8 36 39	12.79	4 , 4	. . .	. .	
	10 10 3	327.247	10 18 30	14.31	2 , 2	3	.	Driving clock stopped.
8	7 48 13	285.387	7 48 47	16.69	4 , 4	2	BN	
	8 4 12	285.566	8 4 27	16.78	4 , 4	.	. .	Interrupted by clouds.
18	10 14 28	29.531	10 14 29	10.83	4 , 4	2	BN	
	10 34 4	27.725	10 33 56	11.04	4 , 4	.		
20	7 59 55	275.701	8 0 30	16.33	4 , 4	2	BN	
	8 18 40	274.719	8 20 42	16.03	4 , 4	. .		
	9 12 30	272.832	9 14 8	16.00	4 , 4	2	BN	
	9 29 16	272.366	9 29 38	15.99	4 , 4	. .		
22	9 47 37	132.153	9 47 39	14.93	4 , 4	3	BN	Moonlight.
	10 6 43	131.423	10 6 57	15.31	4 , 4			
24	9 23 20	23.164	9 27 0	10.92	4 , 4	1	BN	Satellite very faint.
	9 54 4	21.411	9 53 50	10.69	4 , 5			
28	7 53 19	129.725	7 54 27	15.20	4 , 4	2	BN	
	8 13 21	129.202	8 13 2	15.49	4 , 4			
	10 12 56	125.031	10 13 12	15.61	4 , 4	2		
	10 32 22	124.187	10 33 28	15.94	4 , 4			
29	8 6 16	86.215	8 7 24	15.04	4 , 4	2	BN	
	8 25 13	85.949	8 26 59	15.21	4 , 4	.		
	9 3 46	84.096	9 4 8	14.93	4 , 5	2		
	9 24 6	83.580	9 25 51	14.38	4 , 5	. .		
31	8 11 18	306.748	8 12 43	15.65	4 , 4	3	BN	
	8 32 31	305.604	8 32 56	15.52	4 , 1	. .		
	9 16 58	304.325	9 17 5	16.07	4 , 4	3		
	9 39 33	303.695	9 39 54	16.17	4 , 4			
Apr. 1	8 38 9	262.994	8 37 2	15.10	4 , 4	3	BN	
	8 57 56	261.667	8 57 46	14.81	4 , 4	.	. .	
	9 42 53	259.273	9 44 29	14.30	4 , 4	3		
	10 2 11	259.086	10 3 2	14.49	4 , 4	. .		
5	7 54 54	5.541	7 55 7	11.00	4 , 4	2	BN	
	8 19 46	3.576	8 20 38	11.25	4 , 4	.		
7	7 49 36	257.899	7 50 0	14.45	4 , 4	2	BN	
	8 12 9	256.908	8 14 31	14.14	4 , 4	.		
17	9 34 51	338.835	9 34 3	12.32	4 , 4	2	BN	Moonlight.
	10 0 42	337.187	10 0 43	12.49	4 , 4	.	. .	
19	8 36 12	241.220	8 35 52	13.04	4 , 4	3	BN	Satellite very faint. Moonlight.
	8 59 40	240.577	8 59 45	12.36	4 , 5	. . .	. .	

Date	W. M. T.	p	W. M. T.	s	Comp.	See'g	Obs.	Remarks
1913	h m s	°	h m s	″				
Apr. 21	8 30 32	107.420	8 30 55	16.19	4 , 4	2	BN	
	8 49 19	106.772	8 49 58	16.05	4 , 4	. .	.	
22	8 20 34	57.966	8 20 9	12.04	4 , 4	2	BN	
	8 39 20	57.155	8 39 20	12.15	4 , 5	. . .	. .	
24	7 58 15	285.542	7 58 56	16.52	4 , 4	2	BN	
	8 19 0	285.905	8 20 15	16.52	4 , 4			
May 1	8 19 43	223.487	8 20 46	11.25	4 , 4	2	BN	
	8 47 15	221.857	8 48 42	10.74	4 , 4			
3	8 9 44	98.382	8 10 22	15.48	4 , 4	2	BN	
	8 31 44	97.645	8 32 50	15.89	4 , 4			
8	8 20 54	135.286	8 21 20	13.69	4 , 4	3–4	BN	Satellite very faint on account of haze.
	8 49 20	134.880	8 17 37	11.52	4 , 4			
1918								
Dec. 17	12 42 36	269.966	12 45 55	13.32	4 , 4	3	HL	Moonlight. Haze.
	13 28 59	266.174	13 32 18	13.35	4 , 4			
18	13 14 55	181.461	13 12 2	11.07	4 , 4		HL	Moonlight and haze. Good obsns. V.
	14 35 31	177.181	11 34 31	12.38	5 , 4	3		Satellite quite faint. [steady.
19	12 40 17	131.620	12 40 26	16.75	4 , 4	2–3	HL	Moonlight and haze. Sat. v. faint.
	13 18 6	130.090	13 19 9	16.97	4 , 4			Better at last.
28	13 47 50	391.102	13 59 23	17.16	4 , 4	3	HL	
	15 26 18	298.338	15 29 7	16.57	4 , 4	.		Images v. poor for last position angles.
29	12 7 26	257.973	12 11 43	12.94	4 , 4	3–4	HL	Intervals of v. bad seeing.
	13 57 36	249.311	13 58 17	11.90	4 , 4			
1919								
Jan. 6	12 39 59	117.418	12 47 50	16.46	4 , 4	3	HL	
	13 33 31	115.893	13 31 24	16.28	4 , 4			
20	11 6 19	325.550	11 7 20	15.16	4 , 4	2–3	HL	Moisture on eye-pieces.
	11 52 47	323.659	11 56 36	15.32	4 , 4	.		
21	10 28 18	286.903	10 28 15	15.93	4 , 4	3	HL	Stopped by clouds and fog.
24	10 42 24	105.885	10 54 33	15.52	4 , 4	3–4	HL	Windy. Pointings difficult.
	12 2 16	104.339	12 8 21	14.95	4 , 4	.		
26	11 41 41	319.819	11 41 53	15.49	4 , 4	3	HL	
	13 22 43	316.776	13 21 56	16.57	4 , 4	. .		
27	10 31 12	282.735	10 32 56	15.61	4 , 4	2	HL	Haze. Eyepiece fogged occasionally.
	11 11 56	281.489	11 12 51	14.97	4 , 4	.		
29	13 31 21	136.135	13 30 51	16.51	4 , 4	3	HL	
	14 19 52	134.824	14 19 39	16.45	4 , 4	.		
30	10 45 32	100.479	10 49 7	14.71	4 , 4	3	HL	Haze. Satellite too faint to fini
31	13 25 36	9.602	13 28 21	11.86	4 , 4	2–3	HL	
	14 20 10	7.360	11 27 33	11.64	4 , 6	.		Haze.
Feb. 1	11 35 14	314.763	11 35 12	16.59	4 , 4	3	HL	
	13 17 44	311.127	13 17 9	16.62	4 , 4	.	.	
5	12 58 51	90.811	13 4 13	13.37	4 , 4	3–4	HL	
	14 8 27	84.589	14 6 55	12.85	4 , 4	.	.	
6	10 57 16	8.785	11 6 56	11.18	4 , 4	3	HL	
	12 43 25	3.484	12 46 24	11.96	4 , 4			
10	10 15 16	130.185	10 16 15	17.01	4 , 4	3	HL	Moonlight. Satellite faint.
	11 8 30	128.365	11 10 1	17.02	4 , 4	. .	.	
19	9 39 43	303.941	9 41 43	16.71	4 , 4	3	HL	
	10 26 30	302.807	10 27 3	16.86	4 , 4	. .	.	
24	9 42 41	345.145	9 44 17	12.63	4 , 4	2–3	HL	Becoming hazy. Eye-piece fogged oc-
	10 25 6	344.269	10 26 14	12.64	4 , 4	. . .	.	casionally

Date	W. M. T.	p	W. M. T.	s	Comp.	See'g	Obs	Remarks
1919	h m s	°	h m s	″				
Apr. 26	10 58 11	240.645	11 1 3	11.12	4 , 4	3	HL	Eye-piece fogged occasionally.
	11 53 30	237.470	12 1 12	11.21	4 , 4	. . .	. .	
Mar. 3	9 49 17	293.112	9 45 15	17.16	4 , 5	[3]	HL	Became too hazy to observe. Good at first, then very ft. Eye-piece fogged.
24	9 1 34	98.390	9 0 32	14.53	4 , 4	3	HL	
	9 37 48	96.817	9 37 37	13.84	4 , 5	.	.	
25	9 3 8	19.181	9 5 34	9.96	4 , 4	3	HL	
	9 43 49	15.204	9 42 55	10.37	4 , 5	3–4	.	
Apr. 2	8 29 16	267.779	8 28 19	13.34	4 , 4	3–4	HL	
	9 23 8	263.517	9 26 36	13.46	4 , 4	. . .	. .	

Observers: HL = A. HALL; BN = H. E. BURTON. Seeing: 2 = good, 3 = fair, 4 = poor. Magnifying powers used were 388 and 367

Values of micrometer screws were as follows:

1912 Dec. 9 — 1913 May 8, Clark II = 9″.9329 + 0″.0000525 ($t°$ − 50° F.) + 0″.0255 (1in..280 − focal scale)

1918 Dec. 17 — 1919 Apr. 2, Repsold = 20″.8347 + 0″.000022 ($t°$ − 50° F.) + 0″.0535 (0in..810 − focal scale)

The satellite was not observed at the five oppositions intervening between May 1913 and December 1918. Computations based on the foregoing observations, oppositions of 1912–'13 and 1918–'19, are under way and it is intended to publish the results in the *Astronomical Journal*.

Washington, D. C., 1919 Aug. 19.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENNA., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def	1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Jan. 3	12	1	1	1	1	poor	Jan. 27	3	–	2	20	–	fair	Feb. 20	8	–	2	2	1	fair
4	9	–	1	1	3	fair	28	8	–	2	28	1	fair	23	3	2	4	15	3	fair
5	8	1	2	2	3	fair	29	8	–	2	16	3	fair	24	4	1	5	11	2	fair
6	8	-	2	3	1	fair	30	8	1	3	8	2	fair	26	8	1	4	11	2	fair
7	8	–	2	16	1	fair	31	8	2	5	11	3	fair	27	8	–	3	15	4	fair
8	4	2	4	36	–	fair	Feb. 1	8	1	5	21	4	fair	28	5	1	4	16	–	fair
9	8	–	3	30	–	poor	2	8	1	6	32	3	fair	Mar. 1	8	1	5	42	4	fair
10	8	1	4	38	2	fair	3	12	–	6	100	4	v. g.	2	8	–	4	26	3	fair
11	8	2	6	42	3	poor	5	8	–	4	56	1	fair	3	8	–	4	8	–	fair
12	8	–	6	43	3	fair	6	10	2	6	104	2	v. g.	4	8	1	5	8	1	fair
13	2	–	4	32	3	fair	7	8	–	5	88	3	fair	5	7	–	3	5	2	poor
14	8	–	4	15		poor	9	8	–	4	49	2	fair	6	8	–	5	42	3	fair
15	11	2	6	32	3	fair	10	8	–	4	21	3	poor	7	8	1	4	45	3	fair
16	8	2	6	33	3	fair	11	8	–	4	29	3	fair	8	11	–	2	108	3	good
17	2		1	3	–	fair	12	8	–	3	28	2	fair	9	2	–	2	72	1	fair
18	4	–	2	5	–	fair	13	8	–	2	20	1	fair	10	4	3	5	85	4	fair
19	8	1	3	13	2	fair	14	9	–	2	20	1	fair	11	4	–	5	66	3	fair
20	8	1	3	11	2	fair	15	8	1	3	32	4	fair	12	8	–	4	70	3	good
21	8	1	4	6	3	fair	16	8	–	3	20	3	fair	13	7	–	4	50	2	poor
24	8	1	1	2	2	fair	17	8	–	3	22	4	fair	17	10	2	6	20	1	poor
25	8	-	1	1	1	fair	18	8	–	3	12	1	fair	18	9	1	7	24	2	fair
26	12	1	2	15	–	fair	19	8	–	3	15	2	fair	19	8	–	5	12	1	poor

1919	Time	New Grs.	Total Grs	Total Spots	Fac Grs.	Def.
Mar. 20	7	–	3	5	2	poor
21	8	2	5	5	3	fair
22	8	–	3	3	3	fair
23	8	2	3	5	3	fair
24	7	1	4	5	2	fair
25	5	2	6	11	1	fair
26	4	1	6	11	2	fair
27	12	–	3	5	1	poor
28	9	–	3	3	1	poor
29	8	1	4	8	1	fair
30	8	1	5	20	1	good
31	7	1	5	8	1	good
Apr. 1	5	1	5	12	3	fair
2	8	–	5	16	3	fair
3	7	2	6	20	2	fair
4	1	1	6	20	2	fair
6	4		6	26	–	fair
7	8	–	5	33	–	fair
8	7	–	5	42	4	good
9	9	–	5	23	2	fair
10	10	–	3	20	–	poor
11	11	–	2	12	1	poor
12	8	–	2	12	1	poor
13	8	1	2	12	1	fair
14	8	–	2	16	1	poor
17	8	–	1	5	2	poor
18	8	–	1	10	2	fair
19	8	1	2	8	2	fair
20	7	–	2	5	3	fair
21	7	1	3	10	3	fair
22	7	–	2	12	3	fair
23	7	1	3	22	–	fair

1919	Time	New Grs	Total Grs.	Total Spots	Fac. Grs.	Def
Apr. 24	6	1	4	35	1	fair
25	7	1	5	32	1	fair
26	9	–	5	18	2	poor
27	6	2	7	18	3	fair
28	9		6	13	3	fair
29	7	2	7	31	2	fair
30	7	–	6	13	1	fair
May 2	6	2	6	21	2	fair
3	7	–	6	20	2	fair
4	7	–	6	40	3	good
5	7	–	5	40	3	good
6	10	1	5	38	2	fair
8	9	1	6	33	3	fair
9	8	–	5	28	2	poor
12	2	–	2	2	–	v. p.
13	7	1	5	17	2	fair
14	8	–	3	13	1	poor
15	6	1	5	33	3	fair
16	7	–	5	33	2	fair
17	6	1	4	42	2	fair
18	7	2	5	97	3	good
19	7	–	4	103	2	good
20	7		4	100	1	fair
21	11	–	4	63	–	poor
22	12		4	80	2	fair
23	7	–	4	62	2	fair
24	7	1	5	48	4	fair
25	7	–	5	18	3	poor
26	7	–	5	15	2	fair
27	7	1	5	13	1	fair
28	7	–	5	8	1	good
29	7	1	2	9	1	fair

1919	Time	New Grs.	Total Grs	Total Spots	Fac Grs	Def
30	8	2	5	25	1	good
31	7		5	25	1	good
June 1	7	2	7	38	2	fair
2	7	1	8	33	1	fair
3	7	–	7	33	1	fair
4	7	1	7	10	4	good
5	6	2	9	69	3	good
6	6		7	13	2	good
7	9		4	34	1	fair
9	6	2	6	19	3	good
10	5	2	7	24	3	good
11	12	–	5	25	3	fair
12	6	2	7	24	3	fair
13	6	2	9	38	3	fair
14	7	–	8	28	4	fair
15	9	–	5	67	3	fair
16	7	–	5	48	2	good
17	6	1	6	52	4	good
18	6	–	5	48	3	fair
19	6	–	5	85	3	fair
20	12	–	5	96	3	fair
21	7	–	5	50	2	poor
22	7	4	9	58	4	good
23	7	–	9	57	4	good
24	7	–	8	47	4	good
25	7	–	5	30		poor
26	9	–	5	30	–	poor
27	12	–	3	6	–	v. p.
28	9	1	5	37	3	fair
29	7	2	6	24	3	fair
30	7	1	7	15	3	good

A STUDY OF PROPER MOTIONS IN THE CLUSTER *N.G.C.* 663,

By VERA M. GUSHEE

Material. — The proper-motions are based upon measurements of four plates taken with the 40-inch telescope of the Yerkes Observatory, two in 1903 and two in 1916 after an interval of nearly thirteen years.

Method of Measuring. — The plates were measured in four positions, *i. e.*, in both X and Y coördinates direct and reversed. In the case of two of the plates, one at the early and one at the late epoch, where double series of measurements were made in each position, the differences between corresponding coordinates were found to be gratifyingly small — a difference of 0.030 or over being taken as a criterion for re-measurement. Four hundred and thirty stars were measured on the best plate. Later this number was reduced to 209.

Sources of Error — Care was taken to guard against all known sources for systematic error such as those due to changes in the position of the plate in the machine or to changes of temperature. The measurements of two sharply defined specks on the plate were found to indicate very closely the thermal state of the machine.

Solution — After the measured coördinates were combined and corrected for "runs" and division errors of the scale, they were entered into a least square solution and the six plate-constants thus deduced, when substituted back in the equations of condition, gave residuals which are taken to be the individual proper-motions referred to the mean of the stars.

Results. — The columns of the table headed μ_α and μ_δ are the annual proper-motion in right ascension and declination reduced to seconds of arc. Column one gives the number assigned to the star in this investigation; column two, the approximate diameters; columns three and four the measured x and y coordinates for the recent epoch in units of a quarter-millimeter rounded off to the nearest whole number.

A list of the 21 *B. D.* stars which are within a radius of 15′ from the center of the cluster is also appended together with the corresponding serial numbers and positions taken from the A. B. catalog.

The center of the cluster as determined from the mean of the x and y coördinates of 209 stars and located with reference to three of the brighter stars is α 1h 40m, δ 60° 47′ (1916).

The present investigation is the basis of a thesis submitted at the University of Chicago for the degree of Master of Science. It is the writer's intention to publish a more complete discussion of these results in the near future in which it is hoped to give the magnitude of the stars and, if possible, the proper-motion of the cluster as a whole as well as preferential motion within the cluster.

N. G. C. 663.

No.	Diam.	X	Y	μ_α	μ_δ
	mm			″	″
1	0.48	427	467	−0.006	+0.015
2	48	451	458	+ 3	+ 15
3	54	502	499	− 5	+ 14
4	46	531	505	− 1	+ 11
5	35	533	506	− 1	+ 8
6	29	454	457	+ 2	+ 1
7	31	437	439	− 3	− 1
8	0.36	436	437	+0.001	+0.002
9	24	444	448	− 2	− 2
10	26	427	437	0	+ 3
11	24	435	424	− 6	− 3
12	36	457	417	− 3	+ 2
13	19	460	426	+ 1	− 1
14	18	464	428	+ 1	0
15	0.18	475	412	+0.003	−0.002
17	16	420	419	+ 2	− 6
21	18	447	397	− 1	− 2
22	29	490	506	+ 1	+ 2
24	24	492	496	+ 12	− 5
26	14	492	474	0	+ 2
27	22	509	481	− 2	− 1
28	0.24	520	477	+0.003	+0.004
29	19	503	466	− 2	+ 4
30	22	510	470	0	− 1
31	18	509	465	0	+ 6
32	19	515	462	+ 3	− 3
34	17	476	459	− 5	− 3
35	27	497	453	− 3	0
39	0.22	520	443	−0.001	+0.001
41	21	507	433	− 6	− 5
42	36	513	430	− 4	+ 5

No.	Diam.	X	Y	μ_α	μ_δ
	mm			″	″
44	0.40	532	428	+0.012	+0.007
46	15	536	430	+ 5	− 5
47	16	518	422	+ 1	− 9
49	28	537	411	− 5	− 2
52	0.18	486	388	−0.001	0.000
53	16	489	376	− 2	− 5
56	17	533	390	0	− 2
58	38	512	376	− 4	+ 6
59	16	529	372	− 8	+ 1
60	22	546	373	+ 1	− 3
61	15	554	373	+ 7	0
64	0.40	530	354	−0.004	+0.012
65	14	559	386	− 1	− 7
66	14	568	381	− 5	− 7
67	21	595	372	− 1	− 3
69	44	625	420	− 3	+ 12
70	32	604	425	+ 28	+ 4
73	20	567	413	+ 1	− 1
74	0.23	561	421	−0.002	−0.003
79	16	663	416	− 2	− 8
80	16	672	400	+ 13	− 23
81	21	666	379	− 3	− 2
83	28	674	349	− 4	+ 4
84	49	656	330	− 7	+ 28
85	20	661	326	+ 6	− 5
86	0.24	612	325	0.000	+0.002
87	20	598	322	− 1	− 2
89	18	546	299	+ 6	+ 1
91	28	526	312	− 3	+ 6
91_1	32	511	321	− 3	+ 5
92	18	504	341	− 2	− 2
93	32	473	326	0	+ 4

No.	Diam.	X	Y	μ_α	μ_δ
	mm			″	″
94	0.14	466	305	−0.012	−0.012
98	25	460	360	− 1	− 2
99	13	432	358	+ 2	+ 6
100	16	419	346	− 2	− 4
103	16	398	329	+ 1	+ 4
104	29	403	317	+ 3	− 6
105	23	378	329	− 1	+ 2
106	0.23	401	360	−0.003	+0.101
107	15	373	355	+ 2	− 12
108	14	375	380	− 3	− 3
109	18	388	379	− 5	− 2
110	18	409	383	− 2	+ 1
111	20	399	396	− 2	− 2
113	19	376	415	+ 3	− 5
114	0.21	382	442	0.000	+0.002
115	31	406	483	− 4	− 1
116	13	422	476	− 4	− 11
117	26	364	483	+ 6	− 4
119	38	429	530	+ 30	− 1
120	29	454	522	− 3	− 3
122	17	528	529	+ 1	0
123	0.17	550	539	−0.004	−0.004
124	24	574	510	− 2	+ 1
125	30	543	468	0	+ 4
126	15	546	467	+ 1	− 1
127	21	534	458	0	+ 2
128	30	550	449	+ 1	+ 1
129	16	580	485	0	− 6
130	0.16	588	473	+0.005	−0.003
131	18	607	462	+ 8	− 7
132	22	609	546	− 4	− 2
133	19	624	573	− 8	− 15
134	21	575	590	− 6	− 13
135	29	565	605	− 4	+ 4
136	30	599	633	− 4	+ 4
137	0.18	639	651	−0.003	−0.001
138	33	660	626	− 3	+ 3
139	25	524	630	0	+ 3
141	34	451	566	− 5	+ 3
142	16	442	583	+ 3	+ 1
143	38	420	583	0	+ 3
143_1	12	417	581	0	+ 6
148	0.14	374	568	+0.012	−0.010
149	28	354	558	+ 20	− 2

No.	Diam.	X	Y	μ_α	μ_δ
	mm			″	″
150	0.14	362	547	−0.012	−0.004
151	16	342	581	0	− 2
152	22	301	548	− 1	− 3
153	35	304	532	− 6	0
154	13	296	505	+ 2	− 2
156	0.17	328	452	−0.001	−0.004
157	29	301	424	− 1	− 2
158	14	346	419	0	− 3
159	15	306	383	+ 20	− 4
160	26	289	358	+ 4	− 2
161	18	338	366	− 2	− 3
162	11	344	361	+ 6	− 16
163	0.20	328	326	0.000	0.000
165	39	324	306	− 3	+ 3
166	15	319	307	+ 4	− 16
168	14	288	332	− 16	+ 13
169	29	271	317	− 2	+ 2
170	16	374	268	+ 5	+ 2
172	15	406	271	+ 2	− 16
173	0.27	409	238	+0.001	+0.005
175	56	382	203	+ 5	+ 16
177	17	425	177	+ 5	− 6
178	15	432	166	+ 4	− 25
178_1	29	384	170	− 2	+ 8
179	28	460	204	0	− 2
180	16	465	202	+ 5	− 11
181	0.15	503	237	0.000	−0.002
182	17	525	251	− 2	+ 1
183	29	596	189	+ 2	+ 4
185	19	590	274	+ 1	− 2
187	36	640	254		
188	17	635	246		
189	14	663	219		
190	0.27	709	176	−0.001	+0.010
191	18	760	210	0	− 1
195	32	737	374	+ 2	+ 7
196	20	748	396	− 7	+ 9
197	18	775	403	− 7	− 11
198	18	785	395	− 8	− 4
199	18	755	456	− 1	− 20
200	0.17	770	465	+0.005	+0.003
201	21	727	473	− 3	− 9
202	20	692	489	− 1	− 2
203	19	710	556	− 8	+ 3

No.	Diam	X	Y	μ_α	μ_δ
	mm			″	″
204	0.22	705	566	−0.002	0.000
205	18	722	591	− 1	− 6
206	18	764	617	0	+ 2
207	0.15	780	632	+0.010	+0.003
208	30	804	652	+ 9	+ 1
209	33	797	563	+ 1	+ 5
211	18	828	588	− 1	+ 11
221	19	730	761	− 4	+ 4
222	25	678	722	+ 5	− 4
223	21	680	675	+ 1	+ 3
226	0.16	650	701	+0.010	0.000
227	39	629	722	− 8	+ 11
228	22	603	760	+ 19	− 11
234	35	443	775	− 13	+ 2
235	31	444	775	− 4	+ 9
236	48	463	748	− 9	+ 7
237	27	498	741	− 6	− 7
238	0.16	542	708	+0.003	−0.007
239	20	444	679	+ 2	− 11
240	18	356	664	+ 11	0
241	28	379	646	− 7	+ 1
242	12	324	626	− 6	− 2
245	29	246	633	− 1	+ 2
248	20	259	513	− 2	− 5
249	0.18	253	489	−0.002	−0.002
250	15	246	478	− 10	− 4
252	16	242	411	− 1	− 8
253	26	201	343	− 4	+ 1
254	15	238	285	− 8	− 2
255	35	250	275	+ 6	0
256	22	225	264	− 1	− 2
257	0.16	306	261	+0.025	−0.010
258	15	282	240	+ 12	− 4
259	35	285	233	− 9	+ 3
260	31	254	190	− 6	− 5
261	11	213	184	− 8	+ 22
262	26	200	197	+ 2	+ 7
263	29	178	272	0	+ 6
264	0.16	179	283	0.000	−0.002
267	18	180	170	− 7	− 6
267_1	0.21	172	144	+0.001	−0.003
271	39	152	369	− 3	0
276	16	164	433	− 3	− 1
277	16	182	478	− 10	− 3
279	36	155	499	+ 12	− 4
284	0.22	160	528	−0.002	+0.004
285	58	170	551	+ 36	0
286	14	171	556	− 3	− 4
293	17	152	599	− 8	+ 4
305	18	165	698	+ 14	+ 6
306	16	209	674	− 14	+ 3
307	24	217	683	− 7	− 3
315	0.14	411	740	0.000	+0.003
320	27	350	114	+ 6	− 5
321	22	359	124	− 2	− 1
317	16	313	138	− 4	+ 7
326	23	720	127	− 1	+ 1
326_1	16	620	127	+ 8	− 1

B. D. Stars included in the Cluster N. G. C. 663.

Serial No.	B.D. No.	B.D. Mag.	A.R. A.G. 1875	Decl.
	°		h m s	° ′ ″
1	60 331	9.0	1 37 23.29	+60 36 22.0
2	333	9.0	.... 32.02	35 59.3
3	339	8.8	. 50.19	37 50.2
4	343	9.1	38 0.54	38 4.9
8	332	9.5	. .	....
44	342	9.5	. ..	....
58	340	9.5	.	....
64	344	9.5	..	....
69	347	9.3	. . 34.72	34 18.4
84	351	9.0	46.29	30 19.3
87	350	9.5	. ...	....
91	341	9.5	.. ...	....
119	330	9.5	37 23.71	39 10.4
143	329	9.3	.. 20.15	41 32.1
165	325	9.5	. ...	....
175	327	8.5	. 7.33	24 37.8
236	336	9.0	35.97	48 52.2
259	323	9.5	....	....
271	320	9.5	..	....
285	321	8.6	35 50.03	39 59.5
294	318	8.5	.. 34.09	41 29.3

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OBSERVATIONS OF VARIABLE STARS.

By WILLIAM DOBERCK.

(Continued from A. J. 754.)

Y Persei: The H. C. comparison stars were used. The value of the step is 0.09 mag. Maximum (8.2) occurred at 2421971. The period is 248.8 days. Minimum (9.5) occurred at 2421861 (142 days after maximum.) The formula is:

$$\text{Mag.} = 8.92 - 0.67 \sin (x + 77°) - 0.10 \sin (2x + 114°) + 0.03 \sin (3x + 45°)$$

0432	c 1 v 5 f	9.3	0965	a 3 v 3 b	8.3	1546	v 2 c	9.0	1815	b 2 v 1½ c	8.9
0451	v 5 c	8.7	0983	a 3 v 1 b	8.4	1558	c 2 v 1½ d	9.2	1830	d 1 v 1 c	9.2
0509	a 1 v 5 b	8.1	1132	c 2 v 3 f	9.5	1566	v = c	9.2	1839	b 3 v 1 c	9.0
0513	a 1 v 3 b	8.2	1153	d 2 v 1½ c	9.3	1575	c 2 v 3 f	9.6	1845	c 1 v 1 d	9.2
0578	b 3 v 3 c	8.8	1156	v = d	9.2	1577	v 1 e	9.4	1862	c 1 v 3 f	9.5
0592	b 4 v 2 c	8.9	1165	c = v = d	9.2	1601	e 2 v 1 f	9.7	1867	v ½ c	9.1
0606	c 4 v	9.5	1183	b 5 v 2 c	9.0	1615	v = f	9.8	1873	c 2 v 1 d	9.2
0617	v = c	9.5	1188	b 3½ v 2 c	8.9	1625	e 3 v 2 f	9.7	1901	b 2½ v 2 c	8.9
0625	c 2 v	9.3	1206	a 3 v 2 b	8.3	1633	e 1 v 2 f	9.6	1907	c 2 v 3 d	9.2
0745	v 1 a	8.0	1207	a 2 v 1 b	8.4	1641	d 2 v 3 e	9.3	1935	a 1 v	8.2
0760	b 2 v 6 c	8.7	1223	a 1 v	8.2	1643	c 2 v 2 e	9.3	1951	v 1 a	8.0
0775	a 2 v 2 b	8.3	1275	b 5 v 3 d	9.0	1654	f 3½ v 1½ g	10.0	1961	a 1½ v 2½ b	8.2
0784	b 2 v 3 c	8.8	1291	b 3 v = d	9.2	1661	b 3 v 4 c	8.8	1976	a 2½ v 1 b	8.4
0791	b 3 v 5 c	8.8	1307	e 3 v 1 f	9.7	1662	b 4 v 3 c	8.8	1981	v 1 a	8.0
0801	b 3 v 3½ c	8.8	1313	e 2 v 3 f	9.6	1674	b 3 v 3 c	8.8	1997	b 1 v	8.6
0887	e 3 v 2 f	9.7	1492	a 1 v 2 b	8.2	1683	b 1 v	8.6	1998	v 1 b	8.4
0899	e 2 v 4 f	9.6	1501	a 1½ v 2½ b	8.2	1689	v ½ b	8.5	1999	b 1 v	8.6
0924	e 2 v 4 f	9.6	1508	b ½ v	8.6	1711	v 1 b	8.4	2001	a 2 v 1 b	8.4
0952	v = b	8.5	1520	b 3 v 7 c	8.7						
0959	a 3 v 2 b	8.3	1532	b 3 v 3 c	8.8						

X Aurigæ: The H. C. comparison stars were used and also c′(A. S. V. 5) 8.71 and d′(A. S. V. 9) 9.08, which were compared here. The value of the step is 0.095 mag. Maxima occurred at 1010?(8.0), 1335 (8.1), 1675 (8.4), and 1990 (8.4). The shape of the light curve is very variable. Some maxima are sharp (1335) others flat (1675 and 1990). The flatter the maximum the less the brightness. The formula is 2421666 + 163.6 E (8.3). Minimum (12.0) occurred about 95 days after maximum but it has not been well observed. The formula is:

$$\text{Mag.} = 9.97 - 1.90 \sin (x + 74°) + 0.28 \sin (2x + 38°) + 0.06 \sin (3x + 39°) - 0.07 \sin (4x + 27°) - 0.03 \cos 6x$$

0509	c 5 v 4 c′	8.6	0901	v = l	11.4	0984	v = d	8.9	1003	v 2 b	8.1
0577	l 3 v 3 m	11.7	0952	k 1 v 5 l	11.2	0992	c 2 v 2 c′	8.6	1190	c 1 v 3 d	8.6
0618	v = n	12.4	0969	d′ 6 v 2 g	10.0	0999	v 3 c	8.2	1192	v = c	8.5
0625	l 5 v	11.9	0983	d 2 v	9.1	1002	v 3 b	8.0	1286	k 4 v 1 l	11.4

1306	*d* 7 *v* 5 *g*	9.7	1640	*d* 2½ *v* 5 *g*	9.4	1716	*e* 3 *v* 3 *g*	9.7	1985	*v* 2 *c*	8.3
1316	*c'* 2 *v* 2 *d*	8.8	1641	*d* 2 *v* 3 *d'*	9.0	1722	*v* 1 *g*	10.3	1997	*c* 1 *v*	8.6
1328	*a* 5 *v* 2 *b*	8.0	1643	*d* 1½ *v*	9.0	1723	*g* 2 *v* 4 *h*	10.4	1998	*b* 3 *v* 2 *c*	8.4
1339	*v* = *b*	8.2	1660	*c* = *v* 2 *c'*	8.5	1727	*h* 2 *v* = *k*	10.9	1999	*b* 3 *v* 1½ *c*	8.4
1342	*a* 5 *v* 3 *b*	8.0	1662	*v* = *d*	8.9	1729	*v* 1 *k*	11.1	2001	*b* 4 *v* 2 *c*	8.4
1350	*c* 3 *v* 3 *d*	8.7	1671	*c* 1 *v* 5 *d*	8.6	1730	*h* 3 *v* 1 *k*	11.0	2019	*v* = *c*	8.5
1355	*c* 3 *v* 2 *d*	8.7	1673	*v* 1½ *c*	8.4	1951	*v* 4 *f*	10.0	2020	*c* 2 *v*	8.7
1357	*b* 3 *v* 1 *c*	8.5	1675	*v* 1 *c*	8.4	1961	*v* 4 *g*	10.0	2024	*c* 2½ *v* 6 *d*	8.6
1532	*c'* 5 *v* 2 *d'*	9.2	1683	*b* 3 *v* 2 *c*	8.4	1970	*d* 2 *v*	9.1	2057	*h* 3 *v* ½ *k*	11.1
1540	*v* 1½ *g*	10.2	1689	*b* 4 *v* 2 *c*	8.4	1975	*c* 2 *v* 2 *d*	8.7	2058	*k* 1½ *v* 3 *l*	11.3
1621	*l* 2 *v*	11.6	1702	*c* 1 *v* 3 *d*	8.6	1976	*v* = *d*	8.9	2070	*v* = *l*	11.5
1633	*v* 2 *j*	10.2	1710	*c* 5 *v* 2 *d*	8.8	1981	*v* = *c*	8.5			

Y Monocerotis: The H. C. comparison stars were used. The step was assumed to be 0.1 mag. Maximum (9.1) occurred at 2421975. The period is 229.4 days.

0538	*k* 3 *v* = *o*	12.0	0924	*v* = *m*	12.3	1683	*v* 1½ *k*	11.6	1967	*d* 3 *v* 2 *e*	9.3
0562	*v* 2 *g*	10.4	1258	*d* 2 *v*	9.1	1689	*h* 2 *v* 4 *k*	11.1	1975	*e* 1 *v*	8.7
0569	*f* 2 *v* 2 *g*	10.2	1286	*e* 2 *v* 5 *f*	9.5	1710	*v* = ½(*e* + *g*)	10.0	1981	*d* 2 *v* 2 *e*	9.3
0602	*e* 4 *v* 1 *c*	9.2	1306	*e* 1 *v* 4 *f*	9.5	1716	*v* = *f*	9.7	1985	*d* 3 *v* 1 *e*	9.4
0611	*c* 3 *v* 4 *d*	8.8	1328	*v* 2 *g*	10.4	1960	*e* 3 *v* 3 *f*	9.6	1997	*v* = *e*	9.4
0900	*h* 3 *v* 3 *k*	11.3	1677	*l* 3 *v*	12.3						

V Cancri: The H. C. comparison stars were used including *c'*(*A. S. V.* 4) 8.15. The value of the step is 0.075 mag. Maximum (7.6) occurred at 2421719. Minimum (12.3) occurred at 2421321 (146 days after maximum). The period is 272.2 days. The formula is:

$$\text{Mag.} = 9.77 - 2.30 \sin(x + 81^\circ) + 0.30 \sin(2x + 19^\circ) - 0.06 \cos 3x - 0.03 \cos 6x$$

0538	*v* 3 *g*	11.0	0649	*d* 5 *v* 3 *e*	7.6	0991	*n* 3 *v* 5 *o*	9.9	1683	*c'* 3 *v* 1 *h*	8.7
0562	*m* 2 *v*	9.5	0653	*v* 3 *e*	7.6	0992	*n* 1 *v* 3 *o*	10.0	1689	*f* ½ *v*	8.3
0577	*v* = *l*	9.1	0900	*e* 2 *v* 2 *f*	8.0	0999	*o* 3 *v* 3 *p*	10.5	1690	*c'* 2 *v*, *f* 1 *v*	8.3
0588	*c'* 3 *v*	8.4	0927	*f* 1 *v*	8.2	1286	*q* 1 *v* 3½ *s*	11.4	1702	*v* = *e*	7.8
0593	*c'* 3 *v*	8.4	0931	*e* 2 *v* 3 *f*	8.0	1310	*s* 3 *v* = *t*	12.3	1711	*e* 1 *v* 4 *f*	7.9
0602	*e* 2 *v* 1 *f*	8.1	0947	*h* 1 *v* 3 *k*	8.8	1328	*v* = *t*	12.3	1722	*v* 3 *e*	7.6
0611	*v* 4 *e*	7.5	0959	*k* 3 *v* 1 *l*	9.0	1342	*v* = ½(*t* + *u*)	12.5	1729	*e* 1 *v* 2 *c'*	7.9
0616	*e* 1 *v* 1 *c'*	8.0	0965	*h* 2 *v* 3 *l*	9.0	1661	*l* 3 *v* 1 *m*	9.3	1957	*f* 2 *v* 1 *h*	8.6
0625	*d* 3 *v* 3 *e*	7.5	0977	*l* 3 *v* 1 *m*	9.3	1671	*h* 3 *v* 3 *l*	9.0	1960	*c'* 1 *v*	8.2
0640	*v* 2½ *e*	7.6	0983	*m* 3 *v* 2 *n*	9.5	1673	*h* 4 *v* 3 *l*	9.0	1985	*d* 3 *v* 2 *e*	7.5

S Hydræ: The H. C. comparison stars were used, and also *c'*(*A. S. V.* 8) 7.7 compared here. The step has been assumed to be 0.1 mag. Maximum (7.8) occurred at 2421355. The period is 255.5 days.

0577	*v* = *e*	8.3	0931	*m* 3 *v* 3 *n*	10.8	1342	*d* 2 *v* 2 *e*	8.0	1671	*g* 2 *v* 4 *h*	9.1
0593	*c'* 2 *v* 5 *e*	7.9	0947	*v* = *o*	11.5	1355	*c'* 3 *v* 3 *d*	7.7	1677	*v* 1 *h*	9.3
0602	*c'* 1 *v*	7.8	0949	*o* 5 *v* 5 *q*	11.9	1625	*d* 4 *v* 2 *e*	8.1	1683	*h* 1 *v*	9.5
0611	*d* 5 *v* 3 *e*	8.1	1310	*g* 3 *v* 3 *h*	9.2	1640	*e* 1 *v*	8.3	1689	*l* 3 *v* 5 *m*	10.4
0616	*e* 3 *v* 3 *g*	8.6	1328	*v* = *e*	8.2	1643	*v* = *e*	8.2	1960	*v* 1 *m*	10.6
0901	*h* 3 *v* 2 *k*	9.7	1332	*d* 3 *v* 1 *e*	8.1	1660	*g* 1 *v*	9.0			

T Cancri: The H. C. comparison stars were used but *b* was assumed to be 8.53, and *c′* (*A. S. V.* 14) 9.47 from comparisons made here. The value of the step is 0.09. Maximum (8.35) occurred at 2421697, and minimum (9.5) at 2421983. It follows 286 days after maximum. For over three months about maximum the magnitude does not vary more than a step. The period is 478 days. The formula is:

$$\text{Mag.} = 8.84 - 0.57 \sin(x + 70^\circ) + 0.11 \sin(2x + 10^\circ)$$

0538	v = c′	9.5	0952	d 3 v 2 e	9.1	1350	c 1½ v 3½ d	8.6	1683	c 1 v 2 b	8.6
0562	c′ 1 v	9.6	0965	d 3 v 3 c	9.0	1377	a 3 v 3 b	8.3	1686	v = b	8.5
0577	d 1 v	8.9	0984	v 2 g	9.5	1384	b 1½ v	8.7	1702	b 1 v 2 c	8.5
0588	v 2 c′	9.3	0991	e 3 v 3 g	9.5	1626	b 3 v 2 d	8.7	1711	v 2 b	8.4
0602	d 4 v 3 c′	9.2	0999	e 2 v 4 g	9.4	1641	a 4 v 2½ b	8.3	1723	v 1 b	8.1
0616	b 7 v 3 c′	9.2	1003	e 2 v 1 g	9.5	1643	v 2 b	8.4	1729	v 2 b	8.4
0638	c 4 v 2 d	8.7	1012	v = g	9.6	1654	a 2 v 1½ b	8.3	1741	a 1 v 2 b	8.3
0900	d 2½ v 3 c′	9.1	1275	c 4 v 3 b	8.5	1661	a 3 v 3 b	8.3	1957	v 1 d	8.7
0931	v 1 e	9.2	1310	e 1 v 1 b	8.6	1671	v 2 b	8.3	1960	d 3 v 1 c	9.1
0941	v = e	9.3	1328	e 1 v	8.7	1677	a 4 v 2 b	8.3	1975	v = d	8.8
									1985	v = e	9.3

R Leonis Minoris: The H. C. comparison stars were used and also *p′* (*A. S. V.* 15) 10.10 The value of a step is 0.087 at 8.0 mag. A well marked maximum occurred at 2421999. The average magnitude at maximum was 6.6. Nijland's elements are confirmed.

0538	c 6 v 2 g	7.5	0965	v 1 k	8.4	1355	m 4 v 1 n	9.3	1741	m 3 v 1 n	9.3
0577	g 6 v 5 m	8.4	0968	k 1 v	8.6	1375	p 2 v 2 o	9.8	1957	h 5 v 2 k	8.4
0593	v 3 m	8.8	0977	k 3 v 4 m	8.7	1625	d 3 v 1 e	7.0	1960	h 1 v 4 k	8.2
0605	m 3 v	9.3	0983	k 1½ v 3 m	8.7	1640	v 1½ d	6.8	1975	e 2 v 4 g	7.3
0611	m 2½ v 10 o	9.2	0992	k 4 v 1 m	8.9	1641	e 1½ v 4 g	7.3	1985	v 1 d	6.8
0616	m 3 v	9.3	0999	k 1 v 3 m	8.6	1650	e 2 v 4 g	7.3	1997	v 2½ d	6.7
0627	m 3 v 2 n	9.2	1003	m 3 v 5 n	9.2	1661	e 3 v 4 g	7.4	1999	b 3 v 5 d	6.3
0643	n 1½ v	9.5	1018	m 3 v 2 n	9.2	1674	v 2 g	7.5	2001	v 1 d	6.8
0655	p′ 3 v 3 q	10.3	1275	e 5 v 3 g	7.5	1677	g 2 v 3 h	7.8	2020	e 5½ v 2 g	7.5
0900	e 2 v 4 g	7.3	1310	k 1 v 5 m	8.6	1683	v = g	7.7	2024	e 5 v 2½ g	7.5
0901	e 5 v 3 g	7.5	1317	k = v	8.5	1702	k 1 v	8.6	2057	k 2½ v 3½ m	8.7
0931	g 1 v	7.8	1328	m 2 v 5 n	9.1	1716	v = m	8.9	2070	k 2 v 1 m	8.9
0941	g 4 v 5 k	8.0	1332	m 2 v 3 n	9.2	1722	m 2 v 2 n	9.2	2078	m 2 v 1 n	9.3
0947	g 3 v = h	8.1	1350	n 3 v 3 o	9.5	1727	v 1 m	9.0	2083	n 2 v 3 p	9.6

V Leonis: The H. C. comparison stars were used. The step was 0.10 mag. Maximum (8.5) occurred at 2421657. The period is 273.2 days.

0577	b 1 v 4 d	9.0	0900	l 1 v 3 n	12.1	1671	b = v	8.8	1722	g 2 v 1 h	11.6
0593	v 1 d	9.8	1625	e 3 v 2 f	10.5	1677	b 3 v 5 c	9.1	1727	g 1 v 1 h	11.5
0605	v = e	10.4	1640	b 2 v 3 e	9.1	1683	b 4 v 2 c	9.3	1741	n 3 v	12.9
0611	f 2½ v	10.9	1641	b 1 v 4 e	8.9	1689	e 2 v 2 d	9.7	1975	f 1½ v	10.8
0616	v 3 h	11.4	1650	v 2 b	8.6	1702	e 1½ v 1 f	10.5			
0625	m 5 v 5 n	12.5	1661	a 5 v 2 b	8.5	1710	f 3 v 3 g	11.0			

T Canum Venaticorum: The H. C. comparison stars were used. The value of the step is 0.066 mag. at $9\frac{1}{2}$, and 0.156 at 11th magnitude. The maximum (9.0) occurred at 2421275, the minimum (12.6) at 2421163. The minimum follows 178 days after maximum. Compared with PARKHURST's observations made 1898–99 the maximum gives 289.5 and the minimum 290.8 days for the value of the period. Their mean confirms the value adopted at present. There is a slight kink in the curve: from 40 to 30 days before maximum the increase is very slight. After maximum the magnitude does not decrease more than a step during about 35 days. A minute change in the curve near maximum would therefore perceptibly alter the epoch. The formula is:

$$\begin{aligned}\text{Mag.} = 10.37 &- 1.61 \sin (x + 59^\circ)\\ &+0.35 \sin (2x + 12^\circ) - 0.19 \sin (3x - 16^\circ)\\ &-0.09 \cos 4x - 0.03 \cos 5x\end{aligned}$$

0593	*v* 3 *h*	11.7	0952	*v* 3 *d*	9.6	1317	*b* 4 *v* 5 *d*	9.3	1731	*k* 2 *v*	12.9
0596	*v* 3 *h*	11.7	0965	*b* 3 *v* 5 *d*	9.3	1336	*c* 3 *v* 4½ *d*	9.5	1741	*h* 3 *v* 3 *k*	12.4
0605	*v* = *f*	11.3	0977	*a* 2 *v*	9.1	1350	*d* 1 *v* 2 *e*	9.9	1745	*h* 2 *v*	12.5
0616	*e* 5 *v* 5 *f*	10.7	0983	*a* 3 *v* 2 *b*	8.9	1363	*e* 2 *v* 4 *f*	10.5	1761	*h* 1 *v*	12.3
0627	*e* 3 *v* 3 *f*	10.7	0984	*a* 4 *v* 10 *d*	9.2	1374	*d* 2 *v* 3 *e*	9.9	1768	*h* 2 *v*	12.5
0640	*e* 3 *v*	10.3	0992	*b* 4 *v* 3 *e*	9.6	1388	*e* 5 *v* 3 *f*	10.8	1781	*f* 3 *v* 4 *h*	11.7
0653	*v* 3 *e*	9.8	0999	*b* 4 *v* 5 *d*	9.3	1391	*e* 3 *v* 3 *f*	10.7	1784	*e* 3 *v* 3 *f*	10.7
0664	*v* 4 *c*	9.8	1003	*a* 3 *v*	9.1	1411	*f* 4 *v* 4 *g*	11.6	1787	*e* 4 *v* 2 *f*	10.9
0679	*a* 5 *v* 10 *d*	9.2	1012	*b* 3 *v* 5 *d*	9.3	1412	*f* 1 *v*	11.5	1793	*e* 1 *v*	10.1
0688	*v* 1 *a*	8.9	1030	*b* 3 *v* 4 *c*	9.1	1429	*v* = ½(*f* + *g*)	11.6	1812	*e* 2 *v*	10.2
0694	*v* 3 *a*	8.7	1036	*v* = *b*	8.9	1641	*v* 1 *d*	9.7	1826	*d* 2 *v* 1½ *e*	9.9
0707	*v* 2 *a*	8.8	1049	*v* = ½(*a* + *d*)	9.4	1654	*d* 3 *v* 2 *e*	9.9	1827	*d* 2 *v* 3 *e*	9.9
0711	*v* 2 *a*	8.8	1064	*a* 3½ *v* 3 *d*	9.4	1661	*v* 1 *e*	10.0	1843	*a* 3 *v* 2 *d*	9.5
0721	*v* 2 *a*	8.8	1074	*v* = *c*	10.0	1671	*e* 2 *v* 3 *f*	10.5	1856	*a* 2 *v*	8.8
0752	*a* 5 *v* 3 *d*	9.5	1075	*d* 3 *v* 3 *e*	9.9	1677	*e* 2 *v*	10.2	1862	*v* 2½ *d*	9.7
0760	*a* 1 *v*	9.0	1080	*d* 2 *v* 1 *e*	10.0	1683	*e* 3 *v* 3 *f*	10.7	1865	*v* 3 *d*	9.6
0901	*f* 1 *v* 3 *g*	11.5	1083	*e* 2 *v*	10.2	1690	*e* 1 *v*	10.1	1873	*a* 3 *v* 3 *d*	9.4
0931	*v* = *d*	9.8	1310	*b* 2 *v* 5 *d*	9.2	1710	*f* 1 *v* 3 *g*	11.5	1975	*e* 2½ 4 *f*	10.5
						1722	*v* ½ *h*	12.1	1985	*f* 2 *v* 4 *g*	11.5

Y Ursa Majoris: The comparison stars were: *a*(*A. S. V.* 5) 7.87, *b*(7) 8.22, and *c*(9) 8.72. These are H. C. magnitudes. The value of the step is 0.082 mag. This appears to be an irregularly variable star. If PRACKA's elements are confirmed the maximum appears at present to occur 29 days later than the calculated epoch but this is very uncertain.

0548	*a* 1 *v*	7.95	0900	*b* 3 *v* 3 *c*	8.47	1124	*b* 2 *v* 3 *c*	8.42	1746	*b* 3 *v* 2 *c*	8.52
0596	*a* 1 *v*	7.95	0931	*b* 3 *v* 3 *c*	8.47	1293	*b* 3 *v* 5 *c*	8.40	1768	*b* 2 *v* 4 *c*	8.39
0649	*a* 4 *v* ½ *b*	8.18	0947	*b* 3 *v* 4 *c*	8.43	1310	*b* 3 *v* 5 *c*	8.40	1787	*a* 3 *v* 1 *b*	8.13
0664	*b* 2 *v* 5 *c*	8.36	0979	*b* 2 *v* 4 *c*	8.39	1388	*b* 2 *v* 2 *c*	8.47	1793	*a* 1 *v* 3 *b*	7.96
0679	*v* = *b*	8.22	0992	*b* 3 *v* 3 *c*	8.47	1626	*b* 3 *v* 3 *c*	8.47	1796	*a* 2 *v* 3 *b*	8.01
0694	*b* 2 *v*	8.38	1012	*b* 2 *v* 3½ *c*	8.40	1662	*a* 1½ *v* 2½ *b*	8.00	1826	*a* 3 *v* 2 *b*	8.08
0711	*a* 3 *v* 2 *b*	8.08	1040	*b* 5 *v* 2½ *c*	8.55	1675	*b* 2 *v* 5 *c*	8.36	1862	*b* 2 *v*	8.38
0735	*a* 3 *v* 1 *b*	8.13	1053	*b* 4 *v* 3 *c*	8.51	1689	*v* = *b*	8.22	1873	*b* 2 *v*	8.38
0752	*b* 1 *v* 4 *c*	8.32	1074	*b* 2 *v* 3 *c*	8.42	1716	*b* 2 *v* 2 *c*	8.58	1957	*v* = *a*	7.87
0781	*b* 3 *v* 3 *c*	8.47	1116	*a* 2½ *v* 2 *b*	8.06	1730	*b* 3 *v* 2 *c*	8.52	1975	*b* 2 *v*	8.38

R Canum Venaticorum: The H. C. comparison stars were used and also *a*′(*A. S. V.* 1) 7.91, whose magnitude was determined by 10 comparisons with the variable star. The value of a step is 0.080 at 8.0 mag. and 0.128 at 10.0 The observations made before 2421194 indicate a minimum (11.1) at 2420726, and a maximum (7.8) at 2421189. The formula is:

$$\text{Mag.} = 9.26 - 1.51 \sin(x + 74^\circ) + 0.27 \sin(2x + 17^\circ) - 0.09 \sin 3x - 0.08 \sin(4x + 67^\circ)$$

The observations, made after 2421310 indicate a minimum (11.5) at 2421700, and a maximum (7.5) at 2421865. The formula is:

$$\text{Mag.} = 9.44 - 1.72 \sin(x + 95^\circ) + 0.18 \sin(2x + 137^\circ) - 0.25 \sin(3x + 79^\circ) + 0.08 \sin(4x - 45^\circ)$$

Maxima may be expected at 2421527 + 325 E. The minimum occurred on an average 171 days after maximum. Both curves show a kink before the maximum, when the increase in brightness was checked (between the 70th and 45th days before maximum):

0577	α' 4 v	8.2	0992	n 3 v 5 p	10.0	1336	$v = p$	10.4	1761	$v = m$	9.6
0596	$v = \frac{1}{2}(\alpha' + k)$	8.5	1000	o 3 v 3 p	10.3	1357	A 1 v	11.5	1768	k 2 v 4½ n	9.3
0605	v 3 k	8.8	1012	o 2 v 2 p	10.3	1384	p 4 v 3 A	11.0	1777	v 1½ k	9.0
0616	v 3 k	8.8	1031	p 3 v	10.8	1388	A 2 v 3 r	11.5	1784	h 3½ v 1½ k	9.1
0627	v 2 k	8.9	1070	o 4 v 2 p	10.4	1411	p 1½ v	10.6	1793	h 3 v 2 k	9.0
0653	k 3 v 2 n	9.5	1080	o 5 v 3 p	10.3	1429	o 2 v	10.4	1812	v 2 k	8.9
0664	n 1 v 2 o	9.9	1096	o 2 v 4 p	10.3	1641	$v = o$	10.2	1826	e 2 v 5 f	8.2
0679	$v = p$	10.4	1113	$v = k$	9.1	1654	p 2 v	10.7	1827	e 5 v 3 f	8.3
0694	p 2 v	10.7	1116	v 2 k	8.9	1661	p 4 v	10.9	1828	e 3 v 2 f	8.3
0711	p 6 v 4 A	11.0	1126	v 5 k	8.6	1671	p 1 v 3 A	10.7	1843	v 3 e	7.9
0723	p 3 v 4 A	10.8	1132	v 1 h	8.8	1686	$v = A$	11.4	1847	d 1½ v 2½ e	7.9
0752	A 2 v	11.6	1149	$v = \frac{1}{2}(e + k)$	8.6	1702	A 2 v	11.6	1862	b 3 v 3 d	7.5
0901	α' 4 v	8.2	1163	α' 4 v	8.2	1710	p 3 v 2 A	11.0	1865	b 1 v 2½ d	7.5
0931	α' 6 v 4 k	8.6	1168	v 2 α'	7.8	1722	p 3 v 2 A	11.0	1873	b 2 v 3 e	7.3
0947	α' 9 v 2 k	8.9	1170	α' 2 v	8.1	1731	o 3 v 1½ p	10.1	1880	e 2 v	8.3
0965	k 2 v 5 m	9.3	1190	v 3 α'	7.7	1743	o 1½ v 3½ p	10.2	1905	α' 5 v 5 f	8.2
0968	k 2 v 4 m	9.3	1194	v 1 α'	7.8	1744	o ½ v	10.2	1906	v 2 g	8.4
0979	v 1 m	9.5	1310	$v = p$	10.4	1745	o 3 v 3 p	10.3	1907	g 2 v 3 l ?	8.9
0983	$m = v$	9.6	1317	o 2 v 4 p	10.3	1760	k 3 v 1 n	9.6	1913	f 1 v	8.6

T Sagittae: This is now an irregular variable star. There is no trace of periodicity left. The H. C. comparison stars were used. The value of a step is 0.07 mag.

0344	e 2 v 2 e	9.04	0708	f 1 v 4 g	9.43	1475	b 1 v 3 d	8.76	1767	d 2 v 1 e	9.19
0352	$v = e$	.28	0716	e 2 v	.42	1476	b 2 v 2 d	.84	1777	d 1 v 2 e	9.10
0364	$v = e$	.28	0725	f 3 v 4 g	.51	1484	b 2 v 1 d	.79	1781	v 1 d	8.94
0375	e 1 $v = f$	.34	0735	f 1 v 5 g	.41	1492	b 5 v 3 d	.89	1784	d 3 v 2 e	9.17
0395	e 1½ v 2 f	.30	0741	f 3 v 3 g	.57	1501	b 5 v 3 d	8.89	1793	v 1 d	8.94
0399	e 2 v 1 f	.31	0742	f 2 v	.47	1507	d 2 v 3 e	9.12	1796	v 2 d	8.87
0401	e 1 v 3 g	.41	0753	f 2 v 3 g	.52	1517	d 2 v 1 e	.19	1812	d 1½ v 1½ e	9.14
0403	e 1 v 1 f	.30	0791	d 3 v 1 e	.21	1520	v 2 e	9.14	1824	b 3 v 2 d	8.88
0424	v 1 e	.21	0801	e 1 v 2 f	.30	1525	b 4 v 2 d	8.90	1826	b 3 v 1 d	.93
0438	$v = e$	.28	0807	e 1 v	.35	1527	v 2 e	9.14	1830	b 2 v 3 d	.81
0452	v 1 e	.21	1348	v 3 e	.07	1532	d 1½ v 3 e	.10	1838	v 2 d	.87
0485	e 1 v	.38	1357	e 1 v 3 f	.29	1539	d 3 v 2 e	9.17	1844	b 3 v 2 d	.88
0507	e 4 v 4 g	.55	1363	d 1 v 3 e	.08	1547	b 5 v 3 d	8.89	1856	b 3 v 3 d	.85
0653	d 3 v 3 e	.15	1384	e 1 v 1 f	.30	1565	d 1 v 2 e	9.10	1864	v 2 d	8.87
0664	d 2 v 3 e	.12	1391	$v = e$	.28	1576	d 2 v 1½ e	.15	1867	v 2½ e	9.10
0679	$d = v$	.01	1411	$v = e$	.28	1586	e 2 v 2 f	.30	1873	v 1 d	8.94
0691	$v = e$	.28	1429	v 1 e	.21	1727	d 2 v 1 e	.19	1874	$v = e$	9.28
0699	v 1 e	.21	1450	v 2 e	.14	1746	$v = e$	.28	1875	v 2 e	9.14

V Coronae Borealis. The magnitudes of the comparison stars were estimated as follows: A (15h 32m 30s, 40° 12′, 1900) 6.90, B (15h 40m 26s, 39° 58′) 7.39, a (*A. S. V.* 2) 7.73, b(3) 8.06, c(6) 8.70, d(9) 9.24, and e(12) 9.70. The value of the step was 0.057 at 7.0 mag., 0.084 at 8.0, and 0.125 at 9.0. The maximum (7.15) occurred at 2421562, the minimum (9.05) at 2421768; 206 days after maximum. The formula is:

$$\text{Mag.} = 7.97 - 0.88 \sin (x + 65°) + 0.17 \sin 2x - 0.02 \cos 3x + 0.02 \sin (4x + 63°)$$

0596	$v\,2\,b$	7.9	1031	$c\,3\,v\,3\,d$	9.0	1486	$b\,5\,v\,3\,c$	8.5	1760	$b\,2\,v\,4\,c$	8.4
0617	$b\,2\,v\,5\,c$	8.2	1053	$c\,2\,v\,3\,d$	8.9	1493	$v\,1\,b$	8.0	1767	$b\,5\,v\,2\,c$	8.5
0627	$b\,3\,v\,3\,c$	8.4	1064	$c\,5\,v\,3\,d$	9.0	1503	$a\,1\,v\,2\frac{1}{2}\,b$	7.8	1781	$b\,2\,v\,4\,c$	8.3
0653	$c\,2\,v\,2\,d$	9.0	1074	$v\,2\,d$	9.0	1517	$v\,3\,a$	7.6	1787	$b\,5\,v\,2\,c$	8.5
0664	$c\,3\,v\,2\,d$	9.0	1096	$a\,3\,v\,3\,d$	8.5	1527	$B\,2\,v\,4\,a$	7.5	1793	$b\,5\,v\,3\,c$	8.5
0679	$d\,2\,v$	9.5	1120	$b\,2\,v\,5\,c$	8.2	1537	$A\,5\,v\,4\,a$	7.4	1812	$b\,2\,v\,5\frac{1}{2}\,c$	8.2
0699	$v = d$	9.2	1133	$b\,2\,v$	8.2	1537	$v\,1\,B$	7.3	1824	$b = v$	8.1
0723	$c\,5\,v\,3\,d$	9.0	1158	$v\,3\,a$	7.6	1540	$A\,4\frac{1}{2}\,v$	7.2	1830	$v\,1\frac{1}{2}\,b$	7.9
0742	$c\,5\,v\,1\,d$	9.1	1163	$v\,4\,a$	7.5	1547	$A\,3\,v\,4\,B$	7.1	1843	$a\,2\,v\,2\,b$	7.9
0774	$b\,2\,v\,3\,d$	8.5	1190	$v\,4\,a$	7.5	1565	$A\,3\,v\,5\,B$	7.1	1856	$v\,2\,a$	7.6
0791	$b\,2\,v$	8.2	1311	$v\,3\,b$	7.8	1566	$A\,5\,v\,4\,B$	7.2	1862	$B\,2\,v\,3\,a$	7.5
0801	$v\,1\,b$	8.0	1339	$b\,3\,v\,3\,d$	8.6	1576	$A\,3\,v\,2\,B$	7.2	1865	$B\,1\frac{1}{2}\,v\,4\,a$	7.5
0931	$a\,3\,v\,3\,b$	7.9	1342	$v = b$	8.1	1641	$v\,2\,a$	7.6	1873	$A\,5\,v\,2\frac{1}{2}\,B$	7.2
0952	$v\,3\,b$	7.8	1363	$v = c$	8.7	1671	$a\,2\,v\,3\,b$	7.9	1880	$A\,7\,v\,5\,B$	7.2
0965	$b\,2\,v$	8.2	1377	$c\,2\,v\,3\,d$	8.9	1686	$a\,2\,v\,3\,b$	7.9	1905	$A\,3\,v\,5\,B$	7.1
0969	$b\,2\,v$	8.2	1391	$c\,3\,v\,1\,d$	9.1	1702	$a\,5\,v\,2\,b$	8.0	1913	$A\,8\,v\,5\,B$	7.2
0979	$b\,1\frac{1}{2}\,v\,4\,c$	8.2	1392	$c\,2\,v\,2\,d$	9.0	1710	$v = b$	8.1	1925	$A\,5\,v\,5\,B$	7.2
0992	$a\,3\,v\,3\,b$	7.9	1432	$c\,3\,v\,2\,d$	9.0	1722	$b\,1\,v$	8.1	1944	$B\,1\,v$	7.4
1000	$b\,4\,v\,2\,c$	8.5	1474	$b\,5\,v\,3\,c$	8.5	1731	$b\,1\,v$	8.1	1975	$v\,1\,B$	7.3
1012	$c\,1\,v\,3\,d$	8.8	1475	$b\,4\,v\,4\,c$	8.4	1744	$b\,2\,v\,3\,c$	8.3	1985	$B\,3\,v\,2\,a$	7.6

OBSERVATIONS OF COMET 1918 *d* (*SCHORR*),

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By H. E. BURTON.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Date	W. M. T.	Comp.	☄ − ★		App. α	App. δ	Log pΔ		App. Pl. Red. of ★		Seeing
1918	h m s		m s	″	h m s	° ′ ″			s	″	
Nov. 29	14 45 26	t 30, 6	+1 44.43	−1 1.2	4 7 37.63	+11 47 47.4	9.539	0.648	+5.44	+12.7	vp
30	10 42 29	t 50, 10	+1 11.03	−2 1.4	4 7 4.23	+11 49 47.2	8.985n	0.603	+5.44	+12.7	p
Dec. 2	11 56 54	d 10, 10	−0 10.88	+3 18.3	4 5 42.34	+11 55 6.7	8.865	0.690	+5.46	+12.5	p

Under comparisons, t signifies measures were made by transits; d, made with driving clock running.
Seeing: p = poor, vp = very poor

Mean Place of Comparison Star for 1918.0.

α	δ	Authority
h m s	° ′ ″	
4 5 47.76	+11 51 35.9	*A. G. Leipzig I.* 1221

NOTES

Nov. 29. Comet very faint. Not visible in 5-inch finder. Delayed by clouds. Poor observation.
30. Comet faint. Nebulous.

Washington, D. C., July 24, 1919.

OBSERVATIONS OF WOLF'S PERIODIC COMET,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By H. E. BURTON.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Date	Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App δ	Log. $p\Delta$		Red. to App. Pl.		See'g
1918	h m s			m s	′ ″	h m s	° ′ ″			s	″	
July 15	12 13 21	1	40 , 8	+1 48.95	−0 40.4	20 31 59.51	+25 32 51.9	9.001n	0.314	+3.75	+12.6	g
Aug. 2	13 40 18	2	30 , 6	−2 15.73	−3 15.5	20 19 5.25	+26 18 1.8	9.126	0.356	+3.91	+17.5	f
5	10 37 11	3	30 , 6	+1 20.01	+0 54.5	20 16 48.41	+26 15 16.6	8.991n	0.274	+3.91	+18.1	g
13	11 44 4	4	25 , 5	+1 59.14	−0 27.7	20 10 37.35	+26 13 51.7	9.125	0.303	+3.87	+19.7	f
16	12 29 29	5	30 , 10	+0 36.22	−1 7.3	20 8 29.41	+25 52 59.6	9.105	0.372	+3.86	+20.5	f
Sept. 25	8 59 26	6	15 , 3	+5 20.20	+0 1.2	20 7 3.98	+15 16 20.1	9.146	0.554	+3.56	+24.4	f
27	8 58 19	7	25 , 5	+2 42.13	+3 59.6	20 8 41.84	+14 34 9.6	9.174	0.566	+3.58	+24.6	f
28	8 32 5	8	30 , 6	−1 12.96	−1 30.1	20 9 33.77	+14 13 18.7	9.014	0.567	+3.60	+24.9	f
Oct. 1	10 19 37	9	10 , 2	−5 5.94	−2 2.6	20 12 32.32	+13 8 0.4	9.495	0.623	+3.61	+25.1	f
2	9 39 34	10	25 , 5	+1 7.74	+2 47.2	20 13 33.62	+12 47 17.2	9.401	0.611	+3.56	+24.7	f
9	9 27 29	11	25 , 5	−6 37.02	−8 39.1	20 22 5.85	+10 19 45.1	9.417	0.643	+3.58	+25.5	f
23	8 13 40	12	30 , 6	+0 56.67	+0 1.5	20 44 44.82	+ 5 12 49.4	9.269	0.685	+3.54	+25.2	f
31	7 54 59	13	29 , 6	+2 41.00	−5 0.7	21 0 39.37	+ 3 22 2.3	9.254	0.709	+3.53	+25.0	p
Nov. 4	9 31 46	14	24 , 5	+0 47.86	−2 0.9	21 9 28.08	+ 2 16 44.0	9.539	0.726	+3.54	+25.2	p
6	8 0 23	15	30 , 10	−1 14.50	+2 24.2	21 13 49.17	+ 1 17 18.3	9.318	0.725	+3.57	+25.1	f
22	8 16 59	16	30 , 6	+4 3.78	+0 52.8	21 52 54.94	− 1 31 20.4	9.442	0.751	+3.61	+25.4	p
23	8 16 50	17	8 , 8	+0 18.10	+4 56.3	21 55 30.36	− 1 11 1.8	9.445	0.752	+3.64	+25.5	p
26	8 16 47	18	30 , 6	+1 40.35	−7 13.4	22 3 22.53	− 2 8 9.7	9.451	0.756	+3.62	+25.4	p
29	7 30 45	19	8 , 8	+0 23.43	−4 32.6	22 11 16.23	− 2 32 8.3	9.331	0.760	+3.63	+25.4	p
Dec. 5	8 44 10	20	25 , 5	+5 36.72	−0 24.9	22 27 40.65	− 3 12 13.5	9.533	0.759	+3.64	+25.2	p
18	6 51 34	21	25 , 5	−3 2.53	−3 31.4	23 3 36.10	− 4 0 39.8	9.267	0.772	+3.75	+25.1	f
26	6 46 48	22	25 , 5	+0 54.26	−5 11.7	23 26 6.93	− 1 7 38.3	9.284	0.773	+3.74	+24.5	p
1919 Feb. 19	7 42 55	23	25 , 5	−2 24.14	+2 51.2	1 57 0.10	− 0 0 57.6	9.575	0.740	+0.86	− 0.2	p
Mar. 1	8 4 48	24	25 , 5	−1 14.40	−1 5.5	2 22 59.14	+ 1 6 13.0	9.615	0.736	+0.88	− 0.8	f
3	7 40 36	25	25 , 5	−0 44.80	+0 52.4	2 28 4.54	+ 1 19 18.8	9.593	0.734	+0.87	− 1.0	f

All comparisons were made by transits except on Nov. 23 and Nov. 29, when driving clock was used.
Seeing: g = good, f = fair, p = poor.

Mean Places of Comparison Stars for the Beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	20 30 6.81	+25 33 19.7	*A.G. Cam. (Engl.)* 11471	14	21 8 36.68	+ 2 18 19.7	*A.G. Albany* 7429
2	20 21 17.07	+26 50 59.8	*A.G. Cam. (Engl.)* 11261	15	21 15 0.10	+ 1 44 28.7	*A.G. Albany* 7468
3	20 15 24.49	+26 44 4.0	*A.G. Cam. (Engl.)* 11122	16	21 48 47.55	− 1 32 38.6	*A.G. Nicolajew* 5526
4	20 8 34.34	+26 13 59.7	*A.G. Cam. (Engl.)* 10981	17	21 55 8.62	− 1 46 23.6	*A.G.* ⅓ [2 *Straszburg* 7678 + *Nicolajew* 5543]
5	20 7 49.33	+25 53 46.4	*A.G. Cam. (Engl.)* 10962	18	22 1 38.56	− 2 1 21.7	*A.G. Straszburg* 7706
6	20 1 40.22	+15 15 54.5	*A.G.* ½ [*Berlin A* 7915 + *Leipzig I* 7690]	19	22 10 49.17	− 2 28 1.1	*A.G. Straszburg* 7749
7	20 5 56.13	+14 29 45.4	*A.G. Leipzig I* 7747	20	22 22 0.29	− 3 12 13.8	*A.G. Straszburg* 7801
8	20 10 43.13	+14 14 24.2	*A.G. Leipzig I* 7803	21	23 6 34.88	− 3 57 33.5	*A.G. Straszburg* 7989
9	20 17 34.65	+13 9 37.9	*A.G. Leipzig I* 7870	22	23 25 8.93	− 4 2 51.1	*A.G. Straszburg* 8066
10	20 12 22.32	+12 44 5.3	*A.G. Leipzig I* 7819	23	1 59 23.38	− 0 3 48.6	*A.G. Nicolajew* 414
11	20 28 39.29	+10 27 58.7	*A.G. Leipzig I* 7983	24	2 24 12.66	+ 1 7 19.3	*A.G. Nicolajew* 496
12	20 43 44.61	+ 5 42 22.7	*A.G. Leipzig II* 10357	25	2 28 48.47	+ 1 18 27.4	*A.G.* ½ [*Nicolajew* 519 + *Albany* 712]
13	20 57 54.84	+ 3 26 38.0	*A.G. Albany* 7369				

NOTES

July 15. Comet very faint; about 15th mag. Nebulous.
Aug. 2. Comet v. faint. Nebulous.
5. Comet faint.
Sept. 25. Comparison star has faint companion star fol. Stopped by thin clouds.
28. Haze at times.
Oct. 1. Stopped by clouds.
9. Comet seems to be barely visible in 5-inch finder.
23. Visible in 5-inch finder. Seems to have faint tail at position angle about 70°.
31. Visible in 5-inch finder. Haze.
Nov. 4. Barely visible in 5-inch finder.
Dec. 18. Visible in 5-inch finder. Moonlight.
Feb. 19. Could not see comet in 5-inch finder.
Mar. 1. Comet faint. Haze. Poor observation.
3. Comet faint. Poor observation.

An observation was begun on Mar. 18, 1919, but on account of poor seeing and the faintness of the comet it was discontinued after 9 measures of $\Delta\alpha$ and 2 of $\Delta\delta$ were made. No further attempts to observe the comet were made after this date.

The ephemeris by M. KAMENSKY in the *Astronomical Journal* (Nos. 738 and 746) was used in following the comet.

Washington, D. C., July 22, 1919.

1919 EPHEMERIS OF (536) *MERAPI*.

By ERNEST CLARE BOWER

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

The following ephemeris is derived from elements in *C.T.* 1915. Opposition magnitude is 11.3.

G. M. T.	α_{1919}		δ_{1919}		(log r) log ρ
1919	h m		° ′		
Sept. 17.5	2 12.5		−6 26		(0.502)
		5.4		24	
27.5	2 7.1		6 50		0.356
		7.1		19	
Oct. 5.5	2 0.0		7 9		0.349
		8.0		9	
15.5	1 52.0		7 18—		0.347
		8.4		4	
25.5	1 43.6		7 14		0.351
		7.9		19	
Nov. 6.5	1 35.7		6 55		0.360
		6.6		34	
16.5	1 29.1		6 21		0.374
		4.9		49	
26.5	1 24.2		5 32		0.391
		2.9		62	
Dec. 6.5	1 21.3		4 30		0.411
		0.8		73	
16.5	1 20.5		−3 17		(0.508)

An observation by MR. PETERS on 1919 Sept. 27 gives $O - C = -0^m.4, +6'$.

U. S. Naval Observatory, Washington, D. C., 1919 Sept. 30.

ERRATA TO *A. J.* VOL. 32, NO. 749, P. 38.

Errata to *Astronomical Journal*, Volume XXXII, No. 749, page 38, column 2, line 2 and 3: for, "method of WILSON and GINGRICH," read, "WILSON's method."

CONTENTS.

EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS E. E. BARNARD, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD.
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THE
ASTRONOMICAL JOURNAL
FOUNDED BY B. A. GOULD

No. 761

VOL. XXXII ALBANY, N.Y., 1919, DECEMBER 17 NO. 17

MICROMETRIC MEASURES OF DOUBLE STARS,

MADE AT THE YERKES OBSERVATORY,

By F. P. LEAVENWORTH.

The measures given below are a continuation of the work published in *A. J.*, 708. They were made possible through the kindness of PROFESSOR FROST in again giving me a place on the Observatory staff during a part of the summer just past.

Ninety-three measures were made with the forty-inch, and sixty with the twelve-inch.

239 β 1095 0h 24m +29° 5′

	°	″			in.	
19.665	359.7	2.56	6.0	14.0	40	
19.681	357.1	. .	.	. .	40	
1919.67	358.4	2.56	6.0	14.0	2–1*n*	

276 β 1310 0h 26m +22° 32′

A and *B*

1919.665	212.6	3.93	7.0	13.7	40	

A and *C*

19.665	294.3	16.84		13.0	40	
19.676	292.6	16.47	7.0	13.0	40	
1919.67	293.4	16.66	7.0	13.0	2*n*	(1)

479 OΣ 20 0h 48m +18° 32′

19.542	301.6	0.46	6.0	6.7	40	
19.665	300.3	0.64	6.0	7.0	40	
19.678	300.7	. . .	. .	. .	40	
19.681	301.8	0.56	. .	. .	40	
1919.64	301.1	0.55	6.0	6.8	4–3*n*	

711 β 4 1h 15m +10° 55′

A and *B*

1919.665	48.4	0.25	. . .	. . .	40	

AB and *C*

1919.665	249.9	23.47	. . .	13.5	40	

851 β 5 1h 33m +16° 1′

	°	″			in.	
19.676	288.2	. . .	. .	.	40	
19.681	294.0	0.91	7.0	9.0	40	
1919.68	291.1	0.91	7.0	9.0	2–1*n*	

992 β 260 1h 47m +14° 51′

19.676	241.9	1.02	.		40	
19.681	239.8	0.96	8.0	9.0	40	
1919.68	240.8	0.99	8.0	9.0	2*n*	(2)

1508 β 525 2h 52m +21° 8′

1919.665	183.0	0.26	7.0	7.0	40	

1512 Σ 333 2h 52m +20° 52′

19.665	203.9	1.49	5.5	6.0	40	
19.681	203.3	1.39	6.0	6.2	40	
1919.67	203.6	1.44	5.8	6.1	2*n*	

1532 Hu 431 2h 54m +21° 10′

19.665	192.7	1.07	9.5	10.0	40	
19.681	191.6	0.99	9.5	9.7	40	
1919.67	192.2	1.03	9.5	9.8	2*n*	(3)

1581 β 1030 3h 3m +21° 17′

1919.681	145.8	0.64	. . .	.	40	(4)

1720 β 878 3h 21m +22° 23′

1919.665	75.9	. . .	6.0	13.5	40	

1761 Σ 412 3h 27m +24° 4′

1919.665	95.0	0.24	. . .	.	40	

2093 OΣ 77 $4^h\ 8^m$ $+31°\ 24'$

	°	"			m.	
1919.681	231.7	0.50	. .	.	40	

6955 Σ 1865 $14^h\ 35^m$ $+14°\ 15'$

19.536	138.0	1.03	. . .	.	12	
19.542	138.9	0.89	4.2	4.0	12	
19.544	135.0	0.92	4.2	4.0	12	
1919.54	137.3	0.95	4.2	4.0	3*n*	

7031 Σ 1888 $14^h\ 46^m$ $+19°\ 36'$

19.536	72.9	2.79	5.0	7.5	12	
19.547	72.2	2.62	5.0	6.5	12	
19.552	71.5	2.51	5.0	7.0	12	
1919.54	72.2	2.64	5.0	7.0	3*n*	

7070 β 239 $14^h\ 51^m$ $-27°\ 10'$

1919.552	322.9	0.97	.		12	(5)

7211 Σ 1932 $15^h\ 13^m$ $+27°\ 16'$

19.547	17.8	0.72	.	.	12	
19.552	12.6	0.65			12	
19.555	15.1	0.56	.		12	
1919.55	15.2	0.64			3*n*	

7368 Σ 1967 $15^h\ 38^m$ $+26°\ 41'$

19.539	111.2	0.69	4.0	6.5	40	
19.552	115.4	0.64	4.0	7.0	12	
19.555	113.7	0.66	4.0	6.7	12	
1919.55	113.4	0.66	4.0	6.7	3*n*	(6)

7187 Σ 1998 $15^h\ 58^m$ $-11°\ 3'$

A and *B*

19.536	179.7	1.06	. . .	.	12	
19.542	178.7	0.92	.	.	12	
19.544	178.3	1.04	. .	.	12	
1919.54	178.9	1.01		.	3*n*	(7)

AB and *C*

19.536	63.7	7.26	. .	.	12	
19.542	62.9	7.39			12	
19.544	63.2	7.35	.		12	
1919.54	63.3	7.33	.	.	3*n*	

7533 β 120 $16^h\ 5^m$ $-19°\ 9'$

A and *B*

19.547	2.8	0.92	. . .		12	
19.555	1.5	1.03	. . .	. . .	12	
19.564	0.9	0.99	. .		12	
19.566	2.4	0.78	.		12	
1919.56	1.9	0.93	. . .	. . .	4*n*	(8)

C and *D*

	°	"			m.	
19.547	50.3	2.25	.		12	
19.555	49.0	2.27	.		12	
19.564	48.8	2.29		.	12	
19.566	54.0	2.24	.		12	
1919.56	50.5	2.29			4*n*	(9)

AB and *C*

19.564	336.0	41.20	.		12	
19.566	336.8	41.06			12	
1919.56	336.4	41.13			2*n*	

7649 Σ 2055 $16^h\ 25^m$ $+2°\ 15'$

19.536	77.4	0.90	.	.	12	
19.539	79.6	1.05	4.0	5.0	40	
19.547	77.3	0.92	4.0	5.5	12	
19.558	79.8	1.06	. .	. . .	40	
1919.54	78.5	0.98	4.0	5.2	4*n*	

7717 Σ 2084 $16^h\ 37^m$ $+31°\ 49'$

19.564	89.2	1.70	3.0	6.0	12	
19.659	90.4	1.78	. .	.	12	
1919.61	89.8	1.74	3.0	6.0	2*n*	(10)

7891 β 125 $17^h\ 5^m$ $-26°\ 53'$

1919.552	65.7	1.93	8.0	11.0	12	

8038 Σ 2173 $17^h\ 24^m$ $-0°\ 58'$

19.536	153.7	0.83		. .	12	
19.544	149.2	0.80	6.0	6.2	12	
19.555	152.6	1.03	6.0	6.1	12	
1919.54	151.8	0.89	6.0	6.2	3*n*	

8162 A. Clark 7 $17^h\ 42^m$ $+27°\ 48'$

B and *C*

1919.558	224.1	0.89	10.0	10.5	40	(11)

8303 Σ 2262 $17^h\ 56^m$ $-8°\ 11'$

1919.678	262.0	2.00	5.0	5.4	12	(12)

8340 Σ 2272 $17^h\ 59^m$ $+2°\ 33'$

1919.678	134.5	5.38	4.0	6.3	12	(13)

8372 A. Clark 15 $18^h\ 2^m$ $+30°\ 33'$

19.539	354.7	1.50	5.0	10.0	40	
19.555	350.2	1.81	5.0	9.0	12	
19.659	349.9	1.30	.	.	12	
19.678	348.5	.	.	.	12	
1919.61	350.8	1.54	5.0	9.5	4–3*n*	(14)

8380 Σ 2281 $18^h 4^m$ $+18° 58'$

	°	″			in.	
19.539	72.6	0.82	.	. .	40	
19.552	74.9	0.57	6.0	7.5	12	
19.659	77.0	0.59	. . .	. .	12	
19.676	72.9	0.61	.	.	40	
19.678	69.2	0.53	6.0	7.4	12	
1919.62	73.3	0.62	6.0	7.4	5*n*	(15)

8390 β 132 $18^h 4^m$ $-19° 52'$

19.544	212.8	0.96	.	.	12	
19.552	218.8	1.03	6.7	7.0	12	
19.678	212.5	0.92		. . .	12	
1919.59	214.7	0.97	6.7	7.0	3*n*	(16)

8467 Sh 264 $18^h 12^m$ $-18° 40'$

19.555	49.8	17.50	6.5	8.0	12	
19.678	52.3	17.59	.	.	12	
1919.62	51.0	17.54	6.5	8.0	2*n*	

8488 β 48 $18^h 14^m$ $-19° 43'$

1919.552	355.9	2.09	8.0	10.0	12

8520 β 49 $18^h 17^m$ $-19° 38'$

19.552	45.8	8.02	8.0	10.0	12	
19.555	45.4	8.04	8.0	10.5	12	
1919.55	45.6	8.03	8.0	10.2	2*n*	(3)

8569 β 1326 $18^h 22^m$ $+26° 23'$

1919.558	104.7	5.59	6.5	14.0	40

8655 Barnard 10 $18^h 30^m$ $-12° 5'$

1919.539	138.8	0.50	9.0	9.6	40	(2)

8909 β 137 $18^h 50^m$ $+37° 14'$

A and *B*

1919.659	139.3	. . .	8.0	8.2	12

A and *C*

1919.659	143.1	19.98	.	12.0	12	(17)

8933 β 648 $18^h 52^m$ $+32° 45'$

19.550	52.2	1.47	6.0	9.5	40	
19.555	54.9	. . . .	6.5	10.5	12	
19.566	54.9	1.39	6.0	10.0	40	
19.659	44.9	1.33	6.0	9.0	12	
19.676	49.2	1.27		. . .	40	
19.678	48.9	1.37	. .	. .	12	
1919.61	50.8	1.36	6.1	9.8	6–5*n*	(18)

9319 Σ 2525 $19^h 21^m$ $+27° 5'$

	°	″			in	
1919.659	303.8	1.06			12	(19)

9510 *A* 166 $19^h 35^m$ $+23° 14'$

1919.676	237.8	0.81	9.0	9.5	40

9602 Σ 2576 $19^h 41^m$ $+33° 20'$

A and *B*

19.520	279.4	1.63	8.3	8.0	10
19.539	278.3	2.07		.	40
19.561	276.8	1.77	8.5	8.4	40
1919.54	278.2	1.82	8.4	8.2	3*n*

A and *C*

19.539	333.6	18.25	.	15.0	40	
19.561	335.3	.	. . .	.	40	
1919.55	334.4	18.25		15.0	2 1*n*	(1)

A and *D*

19.539	256.6	13.63		14.0	40	
19.561	254.7	13.89		.	40	
1919.55	255.6	13.76	.	14.0	2*n*	(1)

B and *D*

1919.561	256.7	15.91	.	.	10

J 827 $19^h 42^m$ $+18° 20'$

19.550	35.4	3.28	10.5	12.0	40
19.558	32.8	3.32	10.0	11.5	40
1919.55	34.1	3.30	10.2	11.7	2*n*

J 1187 $19^h 42^m$ $+17° 50'$

19.550	193.8	1.17	9.5	9.8	40
19.558	190.2	1.02	9.0	9.5	40
1919.55	192.0	1.10	9.2	9.6	2*n*

9621 Hu 347 $19^h 42^m$ $+18° 59'$

19.550	340.7	0.99	9.0	11.5	40	
19.566	341.9	1.13	8.5	12.5	40	
1919.56	341.3	1.06	8.8	12.0	2*n*	(3)

9643 A. G. Clark 11 $19^h 44^m$ $+18° 51'$

19.550	169.9	0.29	. . .		40	
19.566	168.8	0.31	. .		40	
1919.56	169.4	0.30	.		2*n*	(20)

9651 Hu 349 $19^h 44^m$ $+16° 44'$

A and *B*

	°	″			in.	
1919.566	235.8	2.21	8.3	14.0	40	

A and *CD*

1919.566	29.4	53.28	. .		40	

C and *D*

1919.566	199.0	3.02	12.5	14.0	40	

10363 β 151 $20^h 32^m$ $+14° 11'$

A and *B*

19.536	339.7	0.49		.	12	
19.550	339.4	0.48		.	40	
19.566	337.1	0.50	.	. . .	40	
1919.55	338.7	0.49	. . .	. . .	3*n*	(21)

AB and *C*

19.550	119.6	23.33	.	11.5	40	
19.566	119.7	. .	. . .	. . .	40	
1919.56	119.6	23.33	.	11.5	2–1*n*	

AB and *D*

19.536	328.1	38.43	.	.	12	
19.561	329.0	. . . .	. . .	. . .	40	
1919.55	328.6	38.43	. . .	. . .	2–1*n*	

10520 β 65 $20^h 42^m$ $+5° 34'$

1919.676	190.6	2.08	5.0	8.5	40	(22)

11211 Σ 2822 $21^h 39^m$ $+28° 12'$

1919.550	136.1	1.51	. . .	. .	40	(23)

11222 β 989 $21^h 39^m$ $+25° 6'$

A and *B*

1919.550	91.4	0.25	. .	.	40	(24)

AB and *C*

1919.550	294.4	12.48	. .	.	40	

11275 β 1306 $21^h 44^m$ $+23° 1'$

A and *B*

1919.676	295.2	31.71	. .	. . .	40	

A and *CD*

1919.676	275.0	33.30	. .	.	40	

C and *D*

	°	″			in.	
1919.676	334.4	. . .	.		40	

11732 β 291 $22^h 22^m$ $+3° 55'$

AB and *C*

19.550	124.2	30.85	8.0	14.0	40	
19.566	124.7	30.96	. .	. .	40	
1919.56	124.4	30.90	8.0	14.0	2*n*	

A and *B*

1919.566	178.2	0.42	. .		40	

11743 Σ 2909 $22^h 23^m$ $-0° 38'$

19.522	306.1	3.08	. .	. . .	40	
19.542	305.7	2.90	. .	. . .	40	
1919.53	305.9	2.99	. . .	. . .	2*n*	

11756 β 76 $22^h 23^m$ $-0° 49'$

A and *B*

19.522	344.5	1.56	8.0	9.5	40	
19.542	342.1	1.45	8.0	9.5	40	
19.566	338.6	1.31	. .	. . .	40	
1919.54	341.7	1.44	8.0	9.5	3*n*	

A and *C*

19.522	339.9	45.51	. . .	14.0	40	
19.542	340.3	45.28	. .	14.5	40	
19.550	339.8	45.95	.	14.0	40	
19.566	339.9	. .	. .	. .	40	
1919.54	340.0	45.58	.	14.2	4–3*n*	

J 856 $22^h 23^m$ $+28° 43'$

1919.676	215.8	1.25	9.5	11.0	40	

12008 Ho 482 $22^h 46^m$ $+25° 45'$

1919.581	192.5	0.28		. .	40	(25)

12094 OΣ 483 $22^h 53^m$ $+11° 5'$

19.522	236.7	1.02	. .	. .	40	
19.542	236.4	1.09	6.0	7.5	40	
19.566	232.5	0.93	6.0	7.0	40	
19.676	231.8	0.98	6.0	7.0	40	
1919.58	234.4	1.00	6.0	7.2	4*n*	

12276 β 79 $23^h 11^m$ $-2° 10'$

1919.665	65.3	1.18	8.0	9.7	40	(26)

12290 β 80 23h 13m +4° 45′

	°	″			m.	
19.665	250.8	0.79	8.0	9.0	40	
19.676	245.8	0.81	8.0	9.0	40	
1919.67	248.3	0.80	8.0	9.0	2n	

12432 β 720 23h 28m +30° 40′

19.522	194.3	0.48	.	. . .	40	
19.542	193.8	0.43		. .	40	
1919.53	194.0	0.46		. .	2n	

12650 A 427 23h 51m +27° 4′

19.676	218.7	1.61	8.7	14.0	40	
19.681	222.1	1.64	8.8	13.5	40	
1919.68	220.4	1.62	8.8	13.8	2n	(3)

(1) Change due to the proper-motion of A.

(2) Slow increase in angle and distance.

(3) No motion.

(4) Angle decreasing about 0°.8 a year.

(5) Angle increasing about 0°.3 a year.

(6) Comparison with LEWIS' elements in Mem. R. A. S., Vol. LVI gives

O — C +5°.0 +0″.12

The period in DOBERCK's elements *A. N.* 4296 appears too short, making the distance at this time only 0″.06.

(7) Comparison with AITKEN's ephemeris in *Lick Pub.*, Vol. XII, gives

O — C +0°.1 −0″.09

(8) Change doubtful.

(9) Angle increasing about 0°.1 a year.

(10) Comparison with COMSTOCK's ephemeris, *A. J.*, No. 172, gives

O — C −0°.6 −0″.17

(11) Comparison with AITKEN's ephemeris gives

O — C +8°.0 −0″.05

(12) DOBERCK's orbit, *A. N.* 4063, still represents the observations closely.

O — C +0°.1 +0″.05

(13) Comparisons with LOHSE's ephemeris, *Potsdam*, Vol. XX, and DOBERCK's *A. N.* 1116, give respectively

O — C −0°.4 −0″.07 +0°.7 −0″.06

(14) DOBERCK's elements III represents the angle best and his elements I represent the distance best (*A. N.* 3912).

(15) The distance has apparently not reached a maximum in the first quadrant. The curves in BURNHAM's *Gen. Cat.* and LEWIS' Struve stars, *Mem. R. A. S.*, Vol. LVI, are erroneous in this respect.

(16) Angle decreasing about 0°.6 a year. Distance probably increasing slightly.

(17) Distance increasing.

(18) Comparison with AITKEN's ephemeris gives

O — C +27°.1 +0″.72

(19) Comparison with DOBERCK's ephemeris, *A. N.* 4515, gives

O — C +2°.7 +0″.28

(20) Comparison with VAN BIESBROECK's ephemeris, *A. J.*, No. 692, gives

O — C −2°.9 0″.00

(21) Comparison with LOHSE's ephemeris gives

O — C −0°.4 −0″.03

(22) Angle increasing about 0°.1 a year.

(23) Motion still appears rectilinear.

(24) Comparison with LEWIS' orbit gives

O — C −6°.6 +0″.09

(25) Probably a short period binary.

(26) Angle decreasing about 1°.0 a year.

Minneapolis, Minn.

OBSERVATIONS OF ASTEROIDS,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Wash. M.T.	★	Comp.	⊙ − ★		App. α	App. δ	Log pΔ		Red. of ★ to app. pl.		See'g	Obs.
					(288) *Glanke*							
1916 h m s			m s	′ ″	h m s	° ′ ″			s	″		
Nov. 27 16 33 17	1	t39, 8	−3 38.51	−3 10.5	6 23 32.35	+19 43 36.0	9.489	0.530	+5.54	0.0	f	HL
Dec. 1 14 12 11	2	t25, 5	+2 25.04	+3 30.7	6 20 48.04	+19 46 9.6	8.864	0.460	+5.66	+ 1.2	p	Bn
22 11 27 1	3	t20, 4	+1 18.88	−1 50.2	6 1 46.42	+20 6 28.7	8.791n	0.451	+6.05	+ 2.6	f	Bn
28 10 46 6	4	t34, 7	−3 16.82	+5 5.9	5 55 45.19	+20 13 37.4	8.933n	0.451	+6.15	+ 2.8	f	HL
1918 May 1 12 14 32	5	t30, 6	−4 31.65	+0 57.9	16 55 32.85	−12 58 35.7	9.110n	0.835	+3.47	−10.6	f	HL
2 13 55 7	6	d13, 10	+0 20.27	+0 18.4	15 54 46.87	−12 56 0.4	8.930	0.837	+3.50	−11.1	vp	B
17 12 34 41	7	t40, 8	−0 48.02	+4 36.9	15 42 33.01	−12 24 20.4	8.821	0.834	+3.69	−11.6	g	B
June 4 12 34 15	8	t30, 6	−2 54.16	−4 30.3	15 28 18.32	−12 10 42.1	9.360	0.822	+3.77	−11.8	f	B
5 12 9 18	8	t29, 6	−3 32.47	−4 49.9	15 27 40.02	−12 11 1.6	9.283	0.826	+3.78	−11.7	..	HL
					(433) *Eros*							
1919 July 25 13 4 8	9	t25, 5	+1 38.66	+1 17.7	19 31 36.11	−24 38 46.6	9.344	0.879	+4.64	+14.1	p	Bn
29 10 34 26	10	t25, 5	−1 46.64	+1 19.4	19 24 35.11	−24 14 18.0	8.705n	0.893	+4.65	+13.6	p	Bn
Aug. 2 11 57 27	11	d 8, 8	+0 2.99	−3 22.2	19 17 53.21	−23 47 14.4	9.246	0.882	+4.62	+12.7	vp	Bn
					(447) *Valentine*							
1918 May 8 13 12 22	12	t30, 10	+2 23.64	+0 2.1	16 10 2.78	−19 22 10.5	8.191	0.873	+3.70	− 9.4	p	Bn
14 12 17 27	13	t30, 10	−2 47.66	+1 35.1	16 5 14.08	−19 16 5.4	8.609n	0.872	+3.82	− 9.4	f	Bn
16 11 28 56	14	t30, 10	−1 4.12	+0 40.1	16 3 34.05	−19 13 55.6	9.986n	0.868	+3.85	− 9.8	g	Bn
31 12 8 14	15	t25, 5	+2 13.93	−2 19.1	15 50 42.52	−18 56 18.1	9.045	0.867	+3.97	−11.2	f	Bn
June 4 10 9 39	15	t25, 5	−0 58.19	+2 2.5	15 47 30.40	−18 51 56.4	8.992n	0.868	+3.97	−11.1	f	Bn
8 11 1 44	16	t25, 5	+3 37.63	+3 21.2	15 44 22.24	−18 47 50.1	8.708	0.869	+3.98	−11.7	f	Bn
12 9 46 3	16	t25, 5	+0 46.38	+6 51.5	15 41 31.02	−18 44 19.9	8.841n	0.868	+4.01	−11.8	vp	Bn
					(588) *Achilles*							
1919 Apr. 26 10 59 0	17	t30, 6	−3 26.88	+8 5.6	11 20 26.33	− 5 4 0.5	9.344	0.779	+2.76	−20.5	p	Bn
May 2 11 38 34	18	d 8, 8	+0 8.18	+1 32.3	11 19 13.20	− 4 52 33.1	9.510	0.770	+2.69	−20.4	vp	Bn
3 10 25 15	19	d 8, 8	−0 4.67	+0 45.1	11 19 4.30	− 4 50 53.9	9.328	0.778	+2.69	−20.4	p	Bn
3 11 39 27	21	t25, 5	−3 14.98	+1 59.7	11 19 3.93	− 4 50 46.5	9.519	0.769	+2.71	−20.4	p	Bn
					(886) *Washingtonia*							
1917 Nov. 24 12 33 6	22	t30, 6	+0 41.85	−2 47.0	2 42 13.91	+10 0 2.4	9.382	0.643	+5.16	+23.9	p	Bn
26 11 19 55	22	t21, 5	−0 54.94	+7 21.9	2 40 37.13	+10 10 11.2	9.256	0.633	+5.17	+23.8	f	HL
Dec. 5 9 29 18	23	t25, 5	+3 27.78	−0 40.9	2 34 28.55	+10 59 19.7	8.206n	0.612	+5.17	+24.6	f	Bn
29 10 55 10	24	t30, 6	+2 21.48	+0 34.5	2 28 50.84	+13 36 29.1	9.520	0.623	+5.09	+24.6	p	B
1918 Jan. 9 9 28 22	25	d10, 10	−0 7.82	+9 20.9	2 31 35.68	+14 57 2.8	9.411	0.583	+1.74	+ 8.1	p	B
12 10 30 4	26	t34, 7	+3 49.99	+6 32.4	2 32 53.50	+15 20 7.9	9.567	0.620	+1.72	+ 8.3	f-p	HL
Feb. 4 8 54 28	27	d24, 20	−0 10.71	+1 49.0	2 49 0.68	+18 19 52.9	9.538	0.570	+1.54	+ 7.4	p	B

(288) Glanke: Nov. 27, haze at last. Dec. 28, comparison star too bright; declination settings on it are poor; windy; poorer at last; cross circuit on brushes; wires flashing. May 1, illumination unsatisfactory. May 2, delayed at times by clouds. May 17, very unequal illumination of wires, poor observation. June 4, poor observation. June 5, asteroid faint; haze; poor observation.

(433) Eros: July 25, estimated mag. about 12.5. July 29, poor observation; interrupted by clouds.

(447) Valentine: May 31, a little haze. June 12, windy.

(588) Achilles: May 3, first observation, haze, asteroid faint; second observation, asteroid very faint.

Wash. M.T.	★	Comp.	⊙ − ★		App. α	App. δ	Log $p\Delta$		Red. of ★ to App. Pl.		Seeing	Obs.
					(886) *Washingtonia*							
1918 h m s			m s	′ ″	h m s	° ′ ″			s	″		
Feb. 12 7 58 57	28	d12, 10	−0 19.98	−2 15.8	2 56 48.81	+19 22 57.1	9.473	0.530	+1.50	+ 7.3	p	B
13 7 51 31	30	d12, 10	−0 4.53	−0 27.1	2 57 51.15	+19 30 49.8	9.162	0.524	+1.48	+ 7.2	f	B
Mar. 2 8 2 31	32	d14, 12	−0 13.47	−1 0.2	3 17 41.36	+21 42 37.1	9.584	0.546	+1.33	+ 6.3	f	B
5 8 58 6	33	d14, 12	−0 23.47	+1 52.6	3 21 35.31	+22 5 29.9	9.658	0.612	+1.32	+ 6.1	f	B
15 8 35 54	34	d16, 12	−0 19.00	−3 44.9	3 35 3.87	+23 18 29.2	9.664	0.606	+1.25	+ 5.6	f	B

Nov. 24, clouds passing over. Nov. 26, haze; moonlight; asteroid faint at last. Dec. 5, est. mag. about 13; perhaps 1 mag. fainter than on Nov. 24. Dec. 29, $13^m.0\pm$; moonlight; asteroid faint; poor observation. Jan. 9, $13^m.5\pm$. Jan. 12, could not make transit wires faint enough. Feb. 1, $13^m.5\pm$; asteroid faint at times. Feb. 12, $13^m.5\pm$; asteroid faint at times. Feb. 13, $13^m.5\pm$; asteroid faint. Mar. 2, $14^m.0\pm$. Mar. 5, $14^m.0\pm$; delayed after first half of cos $\delta\Delta\alpha$, because asteroid passed very close to a star; asteroid faint for $\Delta\delta$ and second half of cos $\delta\Delta\alpha$; very faint at last; poor observation. Mar. 15, $14^m.0\pm$.

Comparisons: d = direct measures, clock running; t = transits
Seeing: g = good; f = fair; p = poor, vp = very poor.
Observers: HL = A. Hall; Bx = H. E. Burton; B = Ernest Clare Bower

Mean Places of Comparison Stars for Beginning of Year.

★	α	δ	Authority
	h m s	° ′ ″	
1	6 27 5.32	+19 46 46.5	*A. G. Berlin A.* 2205
2	6 18 17.34	+19 42 37.7	*A. G. Berlin A.* 2108
3	6 0 21.49	+20 8 16.3	*A. G. Berlin A.* 1889 *A. G. Berlin B.* 2164
4	5 58 55.86	+20 8 28.7	Boss *P. G. C.* 1507
5	16 0 1.03	−12 59 23.0	*A. G. Camb. U. S.* 5567
6	15 54 23.10	−12 56 7.7	*A. G. Camb. U. S.* 5540
7	15 43 17.34	−12 28 45.7	*A. G. Camb. U. S.* 5491
8	15 31 8.71	−12 6 0.0	*A. G. Camb. U. S.* 5441
9	19 29 52.81	−24 40 18.4	*Cordoba A.* 13627
10	19 26 17.10	−24 15 51.0	*Cordoba A.* 13590
11	19 17 45.60	−23 44 4.9	*Cordoba A.* 13486
12	16 7 35.44	−19 22 3.2	*A. G. Algiers* 6698
13	16 7 57.92	−19 17 31.1	*A. G. Algiers* 6700
14	16 4 34.92	−19 14 25.9	*A. G. Algiers* 6675
15	15 48 24.62	−18 53 47.8	*A. G. Algiers* 6560
16	15 40 40.63	−18 50 59.6	*A. G. Algiers* 6513
17	11 23 50.45	− 5 11 45.6	*A. G. Straszburg* 4315
18	11 19 2.33	− 4 53 45.0	*A. G. Straszburg* 4296
19	11 19 6.28	− 4 51 18.6	Comp. with 20, 1919 May 3, $\Delta\alpha = +0^m\ 37^s.14$, $\Delta\delta = -1'\ 17''.4$, 1919.0
20	11 18 29.14	− 4 50 1.2	*A. G. Straszburg* 4290
21	11 22 16.20	− 4 52 25.8	*A. G. Straszburg* 4309
22	2 41 26.90	+10 2 25.5	*A. G. Leipzig II* 1015
23	2 30 55.60	+10 59 36.0	*A. G. Leipzig I* 750
24	2 26 24.27	+13 35 30.0	*A. G. Leipzig I* 731
25	2 31 41.76	+14 47 33.8	*A. G. Leipzig I* 754
26	2 29 1.79	+15 13 27.2	*A. G. Leipzig I* 742
27	2 49 9.85	+18 17 56.5	*A. G. Berlin A.* 778
28	2 57 7.29	+19 25 5.6	$12^m.2\pm$ star, comp. with 29, 1918, Feb. 13, $\Delta\alpha = +2^m\ 51^s.64$, $\Delta\delta = +10'\ 10''.2$, 1918.0

★	α	δ	Authority
	h m s	° ′ ″	
29	2 54 15.65	+19 14 55.4	*A. G. Berlin A.* 800
30	2 57 54.20	+19 31 9.7	{ $12^m.0\pm$ star, comp. with 31, 1918, Feb. 13, $\Delta\alpha = -0^m\,34^s.31$, $\Delta\delta = +2'\,29''.2$, 1918.0
31	2 58 28.51	+19 28 49.5	*A. G. Berlin A.* 817
32	3 17 53.50	+21 43 31.0	½ { *Astr. Par.* +22°.03ʰ 20ᵐ, 99; *Astr. Par.* +21 .03 16 , 48
33	3 21 57.49	+22 3 31.2	⅓ { *Astr. Par.* +23°.03ʰ 24ᵐ, 88; *Astr. Par.* +22 .03 20 , 59; *Astr. Par.* +21 .03 24 , 22
34	3 35 21.62	+23 22 8.5	½ { *Astr. Par.* +24°.03ʰ 36ᵐ, 156; *Astr. Par.* +23 .03 32 , 63
35	3 17 53.50	+21 43 31.1	{ 32 comp. with 36, 1918, Mar. 2, $\Delta\alpha = -1^m\,54^s.74$, $\Delta\delta = -1'\,31''.7$, 1918.0
36	3 19 48.24	+21 45 2.8	*A. G. Berlin B.* 1009
37	3 21 57.59	+22 3 30.7	{ 33 comp. with 38, 1918, Mar. 5, $\Delta\alpha = +1^m\,52^s.43$, $\Delta\delta = +4'\,10''.8$, 1918.0
38	3 20 5.16	+21 59 19.9	*A. G. Berlin B.* 1010
39	3 35 21.71	+23 22 8.6	{ 34 comp. with 40, 1918, Mar. 15, $\Delta\alpha = -1^m\,10^s.44$, $\Delta\delta = +8'\,39''.7$, 1918.0
40	3 36 32.15	+23 13 28.9	*A. G. Berlin B.* 1097

Washington, D. C., 1919, Sept. 5.

SEARCH EPHEMERIS FOR GIACOBINI'S COMET, 1900 III,

By FRANK E. SEAGRAVE.

This comet was rediscovered by Dr. ZINNER early in October 1913, and has a period of 6.582 years. It is due to pass perihelion early next June. The ephemeris and constants are based upon these elements as below. The *Jupiter* perturbations have been very small since perihelion passage in 1913.

$$T = 1913 \text{ Nov } 1.983 \text{ G.M.T.}$$
$$\pi = 7^\circ\ 4'\ 33''$$
$$\Omega = 195^\circ\ 36'\ 18''$$
$$i = 30^\circ\ 33'\ 6''$$
$$\varphi = 47^\circ\ 12'\ 15''$$
$$\text{Log } q = 9.97086$$
$$\text{Log } a = 0.54560$$
$$\mu = 539''.000$$

1920 Gr. Midnight	α	δ	Log r	Log Δ
	h m s	° ′ ″		
Jan. 1	17 29 46	−4 31 7	0.33864	0.48029
9	17 46 43	−4 15 54	0.32350	0.46445
17	18 4 49	−3 51 15	0.30758	0.44747
25	18 23 48	−3 15 55	0.29084	0.42919
Feb. 2	18 43 43	−2 29 48	0.27326	0.41001
10	19 4 38	−1 32 7	0.25474	0.38995
18	19 26 41	−0 22 22	0.23528	0.36931
26	19 49 57	+0 59 25	0.21480	0.34823

CONSTANTS

$$x = r(9.99590)\sin(283^\circ\ 31'\ 26'' + u)$$
$$y = r(9.99753)\sin(194^\circ\ 22'\ 16'' + u)$$
$$z = r(9.23880)\sin(321^\circ\ 51'\ 11'' + u)$$

CONTENTS.

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THE NEW SUBTERRANEAN CLOCK ROOM OF THE ARGENTINE NATIONAL OBSERVATORY.

By M. L. Zimmer.

For more than five years the two Riefler clocks in their hermetically sealed cases have been kept in the little room made in the big brick pier which supports the new M. C. instrument. This room has been kept at a uniform temperature by means of an electric heater controlled by a delicate thermostat. This arrangement, in general, gave very satisfactory results; but as we were dependent upon the Cordoba Light and Power Company we would occasionally find the current cut off for periods varying from a few minutes to a few hours. Then, too, the automatic circuit breaker from one cause or another would get out of order from time to time and cause a change of several degrees centigrade in the clock room. These interruptions at once affected the clock rates and were all the more annoying as they frequently happened in the midst of a series of observations.

For these reasons we began, almost from the first, to look for a way to construct a room that would remain at a constant temperature without the aid of any auxilliary apparatus whatever. It was, therefore, decided to carry out the idea formed earlier by Director Perrine, of constructing a clock room at such a distance underground that the temperature would be practically constant.

The Argentine Weather Bureau, which has a station situated at one end of the original Observatory grounds, has for a good many years conducted a series of experiments for determining the temperature of the soil at various depths. The experiments show that practically all daily variation disappears at a depth of 50 cm. and that at a depth of ten metres the temperature is practically constant the year round.

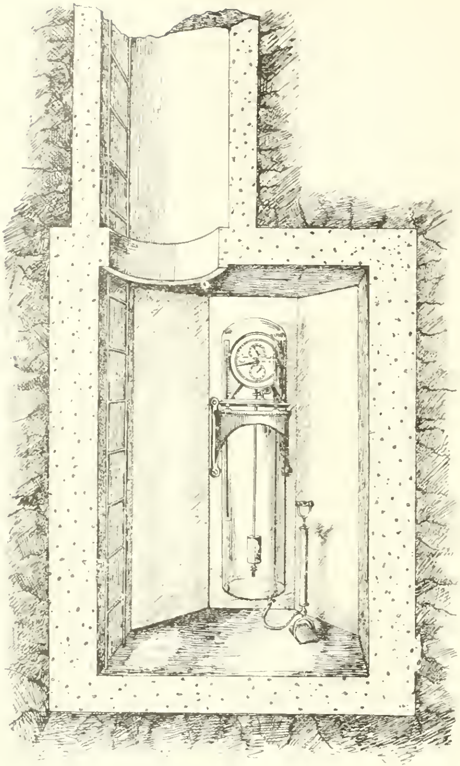
Accordingly, a hole two metres in diameter was sunk to a depth of ten metres and a half and the room constructed according to the plan shown in the figure, of reinforced concrete treated with "Ceresita" a waterproofing mixture which renders the hardened concrete absolutely impervious to water or moisture. The side walls have an average thickness of 25 cm. and the room is 2.20 m. high. The top which supports the chimney and column of earth is reinforced with several five-inch I-beams and is 40 cm. thick. The walls of the chimney have an average thickness of 15 cm., being about twice as thick at the bottom as at the top. This room is provided with a space for a third clock, if necessary, and is amply large to permit of two men working in it at the same time. The room is located under what is planned to be the main building in order to give added protection to the ground above against temperature changes.

At first it was feared that we might find difficulty in keeping moisture out, but no trouble whatsoever in that respect has been experienced since the walls became thoroughly dry. Towards the last a few buckets of quick-lime were placed in the room to hasten the process.

The clocks have been installed and the circular iron door clamped into place on the lead gasket at the bottom of the man-hole, or chimney, as shown in the cut, thus making the room almost, if not quite, hermetically sealed.

The batteries both for the electric wind and chronograph are kept in a small room in the Observatory where they are conveniently changed or adjusted. Delicate galvanometers have been placed in the circuit of the electric wind in order to indicate the number of seconds between successive windings. The Riefler clock in the observing room, which is synchronized with one of the standard clocks in the underground room, gives us at all times the exact time of the standard clock, thus removing all necessity for descending into the room below

At this depth surface vibrations should be greatly diminished, if not entirely nullified, and as there is no diurnal variation of temperature we should expect the rates in this room to be better even than those in the old one where the conditions, although very good

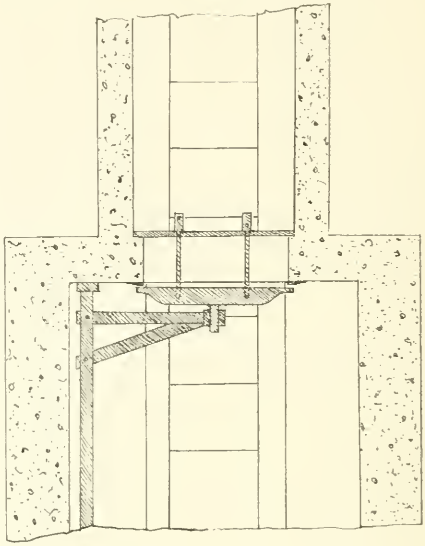


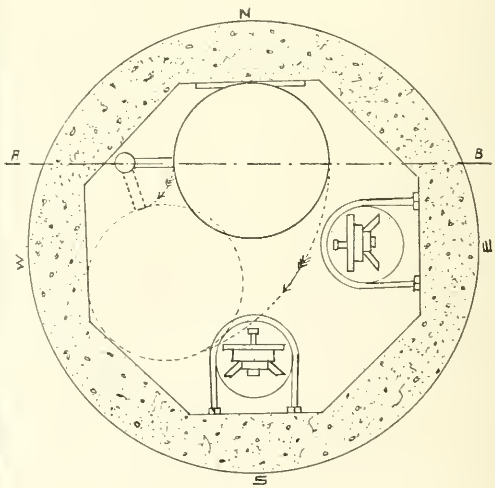
SCALE: 1:30

in general, were rather frequently disturbed. Unfortunately Cordoba is visited rather often by earthquake shocks, some of which, though of slow vibration-period, are of sufficient intensity to actually stop the clocks. These disturbances we are, of course, helpless to overcome. In places where earthquake shocks are not prevalent such a clock room should give conditions that would lead us to expect uniform rates for periods of a whole year, a condition which, to my knowledge, has not even been approximated.

The total cost of construction is so small, and the rates obtainable under such constant conditions so superior, that no observatory can afford, in my opinion, to undertake meridian circle work without putting its clock in some such room.

Observatorio Nacional Argentino,
Córdoba, May, 1919.





SCALE 1:25

Note added by the Director —

The detailed plans of this clock-room are due almost entirely to Mr. Zimmer and are a great improvement in several ways over the very general plan which I had in mind at first. It is so satisfactory that I do not see how it can be greatly improved either in the way of efficiency or simplicity.

C. D. Perrine.

DECLINATIONS OF 182 STARS,

By SAMUEL G. BARTON

The following declinations were obtained by measuring their difference of declination from the stars of Boss's *Preliminary General Catalogue*. The differences were measured with the micrometer of the zenith telescope of the Flower observatory, between October 1916 and August 1918. Observations were taken with the telescope in both east and west positions. All of the stars observed are contained in the *A. G. Bonn* catalogue, that is the declinations are between 40° and 50° north. More detailed results will be given later in the publications of the Flower Observatory.

The columns give respectively the Bonn number of the star observed, its magnitude and right ascension as given in the catalogue and the observed declination reduced to 1875 with the constants of the catalogue, the differences of declination observed minus Bonn, the resulting proper-motion, the number of the Boss star used for comparison and the number of observations. Where the star is contained in the *Catalogue of Proper-Motion Stars*, Publications of the Cincinnati Observatory No. 18, the fact is noted.

A. G. Bonn	Mag.	R.A. 1875	Dec. 1875	diff.	μ′	Boss	n
		h m s	° ′ ″	″	″		
101	7.3	0 6 5	+43 37 13.15	– .15	–.003	66	4
146	6.6	0 8 45	43 30 29.30	– 1.60	–.037	66	5
259	7.0	0 16 25	43 49 53.61	– 0.19	–.004	82	4
532	8.0	0 34 34	44 7 36.34	+ 2.54	+.058	180	4
595	6.8	0 39 16	44 10 39.09	– 2.01	–.060	180	6
639	7.6	0 41 38	44 17 24.33	– 0.37	–.009	180	4
789	7.7	0 51 38	44 16 49.05	– 2.85	–.075	180	6
1180	8.2	1 17 44	44 57 22.65	– 0.75	–.017	304	5
1385	8.1	1 30 51	45 1 34.83	– 2.07	–.066	304	5
1390	7.4	1 31 1	44 45 44.69	+ 0.09	+.003	321	4
1459	7.0	1 35 41	44 41 27.59	– 0.41	–.011	321	4
1497	8.0	1 38 53	40 21 23.27	– 2.33	–.065	420	6
1663	6.7	1 50 22	40 9 3.22	– 4.18	–.128	420	9
1681	8.3	1 50 50	40 18 10.18	– 1.22	–.029	420	4
1788	8.4	1 58 27	46 27 5.13	+ 0.23	+.006	529	6
1855	8.2	2 2 59	46 44 44.01	– 1.09	–.025	529	6
1863	8.3	2 3 33	46 37 4.86	+ 0.06	+.001	529	5
1904	8.3	2 6 20	46 42 5.12	+ 0.92	+.026	529	6
2032	7.4	2 16 22	46 48 12.46	+ 0.96	+.022	522	4
2032	7.4	2 16 22	46 48 12.25	+ 0.75	+.017	529	4
2122	8.3	2 23 38	43 55 56.27	+ 0.07	+.002	619	5
2251	7.4	2 32 31	43 33 5.68	– 1.22	–.028	619	4
2376	7.0	2 39 22	43 44 45.18	– 0.82	–.020	619	6
2408	8.0	2 41 13	46 37 12.75	– 1.65	–.038	672	4
2463	7.4	2 45 36	46 38 50.83	– 2.37	–.076	672	5
2483	7.3	2 47 8	46 47 38.38	– 1.32	–.031	672	5
2491	6.9	2 48 7	46 49 26.98	– 0.99	–.027	672	5
2564	6.6	2 54 22	46 37 0.27	– 1.83	–.048	672	6
2622	7.0	2 59 14	46 49 26.28	– 0.12	–.003	672	4
2710	8.0	3 6 15	46 41 10.21	– 0.19	–.005	672	5
2767	7.9	3 11 9	43 32 47.27	– 0.43	–.010	740	5
2779	7.9	3 11 48	45 25 3.05	– 0.85	–.020	805	4
2781	7.4	3 11 54	45 42 36.43	– 0.57	–.015	805	5
3081	8.0	3 31 57	45 36 54.03	– 0.17	–.004	805	4
3089	8.0	3 32 34	45 29 19.60	+ 0.50	+.013	805	2
3089	8.0	3 32 34	+45 29 19.65	+ 0.55	+.014	853	2
3126	8.0	3 36 0	+45 38 24.29	– 4.61	–.119	805	4
3145	8.1	3 37 11	48 24 29.19	– 0.51	–.013	889	4
3277	8.8	3 48 58	48 22 9.02	– 1.18	–.031	889	4
3287	8.0	3 50 15	48 24 1.71	+ 0.31	+.007	889	7
3333	7.8	3 54 14	48 29 23.37	– 1.33	–.032	889	4
3346	8.0	3 54 49	48 18 44.45	– 0.15	–.004	889	4
3401	7.4	3 59 29	49 51 48.82	– 1.08	–.028	990	6
3695	7.5	4 25 18	49 51 30.11	– 0.79	–.020	1102	4
3762	7.9	4 31 35	49 49 9.95	– 2.65	–.066	1102	4
3830	8.0	4 38 4	42 45 51.88	– 2.02	–.044	1060	4
3851	8.1	4 39 23	49 51 48.19	– 1.51	–.038	1102	4
3967	7.3	4 47 28	49 43 18.86	– 5.24	–.146	1102	5
4097	6.6	4 56 11	46 44 19.69	+ 0.09	+.002	1230	4
4556	7.4	5 25 46	49 30 35.43	– 0.67	–.018	1411	4
4583	8.3	5 27 31	49 42 52.88	– 0.02	–.000	1411	5
4740	8.1	5 40 12	49 47 47.40	– 0.80	–.021	1111	5
4857	8.2	5 49 4	43 11 4.10	– 1.20	–.027	1506	4
4895	8.1	5 51 13	43 10 6.44	– 0.66	–.016	1506	6
5030	7.3	6 0 39	43 9 23.35	– 0.65	–.015	1506	6
5059	7.4	6 2 29	43 11 8.40	0.00	.000	1506	6
5081	8.4	6 4 4	49 29 2.95	– 0.15	–.004	1606	4
5122	7.4	6 7 41	49 31 26.30	+ 0.10	+.003	1606	5
5352	7.4	6 26 52	43 48 3.88	– 0.02	–.001	1724	4
5523	7.6	6 40 20	43 53 44.06	– 2.64	–.059	1724	4
5567	8.1	6 43 40	42 45 51.99	+ 0.39	+.009	1694	4
5683	8.5	6 52 37	47 16 52.01	+ 0.41	+.010	1860	4
5706	7.8	6 54 27	47 26 10.68	+ 2.98	+.074	1860	4
5711	7.7	6 54 42	47 13 40.97	+ 1.17	+.028	1860	7
5730	8.5	6 56 47	47 15 24.98	– 2.82	–.067	1860	5
5819	7.5	7 4 19	47 28 22.30	+ 0.40	+.001	1860	4
5871	8.1	7 9 5	47 29 41.06	+ 2.16	+.059	1860	4
5876	7.8	7 9 22	47 21 28.10	– 1.10	–.030	1860	7
5924	8.0	7 14 29	40 56 5.75	+ 1.55	+.038	1919	4
5980	7.4	7 19 8	46 32 10.42	– 3.28	–.087	1986	4
5986	7.9	7 19 31	40 54 22.92	– 0.38	–.010	1919	4
5996	8.2	7 20 13	+47 32 34.07	– 0.03	–.001	1860	4

A. G. Bonn	Mag.	R. A. 1875	Dec. 1875	diff.	μ′	Boss	n
		h m s	° ′ ″	″	″		
6049	7.3	7 25 4	+46 24 59.99	− 3.81	−.087	1986	6
6092	8.2	7 28 45	41 3 35.07	+ 0.97	+.022	1919	4
6116	7.4	7 30 50	40 57 7.54	+ 0.04	+.001	1919	4
6120	8.6	7 31 14	47 50 3.18	+ 0.68	+.016	2079	5
6154	8.5	7 33 43	47 40 57.50	− 0.20	−.005	2076	4
6195	8.3	7 37 39	46 23 35.74	− 2.46	−.076	1986	4
6201	7.7	7 38 13	47 38 24.14	+ 0.64	+.015	2076	4
6215	8.2	7 39 21	48 4 30.58	− 9.22	−.241	2079	5
6312	8.3	7 49 30	42 59 4.98	− 2.12	−.063	2148	4
6315	7.7	7 49 51	43 50 12.73	+ 0.73	+.016	2142	4
6324	8.5	7 50 52	48 7 19.17	− 2.23	−.052	2079	4
6436	8.4	8 2 50	43 46 28.04	+ 0.34	+.007	2142	4
6450	8.2	8 4 32	43 22 20.25	− 1.55	−.044	2142	4
6466	7.1	8 6 13	43 24 40.28	− 0.52	−.012	2142	5
6499	7.4	8 9 17	48 6 33.50	+ 0.70	+.017	2142	4
6648	7.7	8 24 18	42 33 36.71	− 0.99	−.024	2220	4
6652	8.2	8 24 50	42 25 3.55	− 1.85	−.044	2220	4
6654	8.2	8 24 58	42 10 47.84	+ 0.24	+.006	2333	5
6668	8.6	8 27 8	42 10 53.83	−28.77	−.612	2333	4
6747	8.0	8 35 20	45 54 4.96	− 0.54	−.013	2392	4
6758	7.4	8 36 45	44 5 58.99	− 0.81	−.019	2368	4
6769	8.0	8 37 22	44 5 13.96	− 0.14	−.003	2368	5
6785	8.2	8 39 31	42 10 33.62	− 1.18	−.027	2333	5
6840	8.0	8 47 27	42 9 8.20	− 0.60	−.012	2333	4
6846	8.0	8 47 45	44 9 7.54	+ 0.74	+.017	2368	5
6854	8.1	8 48 37	48 57 19.04	− 1.56	−.035	2432	5
6885	8.6	8 53 15	44 10 4.55	− 0.75	−.017	2368	4
6912	7.7	8 56 10	43 56 5.92	− 1.28	−.031	2465	4
6916	7.9	8 56 35	43 57 4.54	− 2.86	−.069	2465	4
6965	8.2	9 1 26	47 30 51.69	− 1.41	−.032	2484	4
6995	7.9	9 5 12	47 30 8.67	+ 0.57	+.015	2484	4
7030	8.2	9 8 55	43 36 15.98	+ 0.88	+.019	2465	5
7065	7.1	9 13 8	45 53 53.47	− 1.43	−.033	2531	4
7168	7.0	9 25 2	46 3 54.01	− 0.89	−.023	2531	6
7176	8.2	9 26 8	46 35 27.04	+ 0.24	+.007	2626	4
7183	8.1	9 27 27	40 32 39.42	+ 0.42	+.001	2601	5
7186	8.3	9 27 34	40 30 42.76	+ 1.16	+.038	2601	4
7204	8.3	9 29 44	46 27 51.54	− 3.56	−.079	2626	5
7248	8.6	9 34 44	46 5 5.73	− 0.27	−.007	2531	4
7280	8.0	9 37 58	46 26 37.91	+ 0.81	+.018	2626	5
7282	7.5	9 38 22	40 24 41.20	+ 1.50	+.041	2601	4
7283	8.5	9 38 21	40 26 42.38	+ 0.48	+.012	2601	5
7339	7.9	9 44 32	41 33 17.48	− 0.02	.000	2665	1
7373	8.5	9 49 19	46 29 49.20	− 4.20	−.102	2626	4
7444	7.7	9 58 7	41 39 3.58	+ 0.48	+.012	2665	5
7451	8.6	9 58 34	41 41 49.06	− 0.24	−.006	2665	4
7495	7.7	10 3 57	42 20 47.52	− 1.78	−.040	2773	4
7541	6.8	10 9 48	42 5 23.98	− 1.92	−.044	2773	4
7568	8.6	10 13 34	42 14 28.26	− 0.04	−.001	2773	4
7590	8.7	10 18 9	+49 13 41.23	− 0.97	−.025	2806	5
7628	7.0	10 20 21	+49 35 59.82	+ 1.82	+.045	2806	4
7646	8.2	10 23 4	42 6 54.18	− 1.62	−.034	2773	4
7716	8.0	10 33 29	42 10 39.83	− 0.97	−.023	2773	4
7725	8.0	10 35 45	42 33 54.03	+ 0.83	+.018	2912	5
7744	7.7	10 37 45	41 2 13.41	+ 0.11	+.003	2920	5
7793	7.1	10 45 36	40 50 7.44	− 2.76	−.062	2920	6
7867	8.0	10 54 35	42 31 52.31	− 0.09	−.002	2912	5
7917	8.4	11 2 40	42 35 38.72	− 6.28	−.130	2912	4
7943	7.8	11 7 47	44 0 43.97	− 4.83	−.108	2995	4
7992	8.4	11 13 39	44 4 53.19	+ 0.29	+.006	2995	4
9455	7.2	14 23 16	49 57 23.30	+ 0.90	+.022	3733	5
9987	8.2	15 25 44	40 7 24.36	− 0.34	−.008	3922	4
10005	7.3	15 27 10	40 6 8.17	+ 1.47	+.037	3922	5
10240	7.4	15 54 17	43 34 16.58	− 1.22	−.028	4054	4
10318	7.3	16 1 24	44 3 29.42	+ 0.52	+.011	4124	4
10403	8.1	16 8 40	43 58 8.06	− 0.74	−.017	4123	4
10601	8.3	16 29 25	42 7 47.41	− 0.89	−.020	4201	4
10670	8.1	16 36 41	42 23 17.40	− 2.10	−.054	4201	5
10845	7.2	16 53 31	43 52 37.60	0.00	.000	4349	4
10899	8.6	16 57 35	42 59 46.07	− 1.33	−.031	4305	4
11029	7.3	17 8 35	43 52 55.55	+ 8.05	+.177	4349	4
11050	8.4	17 11 37	46 8 27.29	− 2.01	−.046	4408	7
11196	8.3	17 23 34	46 22 41.75	− 5.45	−.136	4408	4
11209	6.8	17 24 52	41 29 58.97	− 0.03	−.001	4484	4
11253	7.4	17 28 44	46 25 11.65	− 1.05	−.028	4408	5
11489	8.1	17 47 31	48 25 48.90	+ 1.00	+.028	4514	4
11489	8.1	17 47 31	48 25 48.71	+ 0.81	+.023	4572	4
11579	7.3	17 54 14	48 18 29.00	+ 0.60	+.015	4514	2
11579	7.3	17 54 14	48 18 29.05	+ 0.65	+.016	4572	3
11618	8.0	17 57 20	48 24 45.30	− 0.70	−.017	4572	4
11630	6.9	17 57 48	48 28 1.86	+ 1.46	+.036	4514	2
11630	6.9	17 57 48	48 28 0.98	+ 0.58	+.014	4572	3
11763	7.3	18 6 38	48 22 30.08	+ 3.38	+.099	4572	5
11786	7.3	18 8 18	48 15 38.01	− 0.99	−.024	4572	4
11805	8.0	18 9 20	49 3 58.47	− 0.53	−.013	4653	6
11848	6.7	18 13 8	48 19 25.27	+ 0.07	+.002	4572	4
11833	6.8	18 11 45	49 6 57.58	+ 2.58	+.072	4653	5
12067	8.0	18 27 53	44 55 39.53	−13.57	−.387	4741	4
12109	8.0	18 30 36	48 57 15.88	− 1.32	−.031	4653	4
12287	8.1	18 41 42	41 16 24.21	+ 0.21	+.004	4805	3
12287	8.1	18 41 42	41 16 23.75	− 0.25	−.005	4870	4
12380	7.8	18 47 48	41 18 53.87	− 0.63	−.013	4805	2
12380	7.8	18 47 48	41 16 53.62	− 0.88	−.019	4870	6
12528	7.1	18 57 39	41 18 36.35	+ 2.25	+.048	4805	4
12528	7.1	18 57 39	41 18 35.90	+ 1.80	+.039	4870	6
12579	8.2	19 0 49	41 14 27.94	− 2.06	−.049	4870	6
12771	8.1	19 11 29	41 22 25.68	− 0.82	−.018	4870	4
15575	7.1	21 24 26	49 14 57.92	+ 1.92	+.055	5539	4
16284	7.7	21 57 36	42 12 41.37	+ 1.57	+.038	5737	4
16371	7.6	22 2 39	+40 20 32.96	− 0.84	−.018	5737	4

A. G. Bonn	Mag.	R. A. 1875	Dec. 1875	diff	μ'	Boss	n
		h m s	° ′ ″	″			
16557	8.0	22 12 26	+42 9 24.14	+ 3.54	+.086	5737	4
16953	7.0	22 33 8	44 1 9.75	+ 1.05	+.030	5876	4
17387	7.8	22 57 30	48 9 27.80	− 0.70	−.020	5993	4
17465	8.2	23 1 51	48 22 6.26	− 0.14	−.004	5993	5
17514	7.6	23 4 37	48 20 20.90	+ 3.00	+.079	5993	5
17658	7.4	23 13 18	48 14 9.24	+ 1.74	+.054	5993	5
17836	7.7	23 23 43	48 25 5.63	− 0.17	−.004	5993	4
17848	6.5	23 24 10	48 26 39.10	+ 0.30	+.007	5993	4
17958	7.8	23 30 51	49 29 56.28	− 0.32	−.094	6101	5
18044	7.0	23 34 59	+45 31 34.20	− 1.40	−.041	6101	5

NOTES

1663	Ci. 257
3967	Ci. 627
6668	Ci. 1000
6916	Ci. 1071
7283	Ci. 1157
7373	Double Σ 1394
11029	Ci. 2295
12067	Ci. 2131
18044	Ci. 3107

Flower Observatory,
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ON THE ORBIT OF *p ERIDANI = DUNLOP* 5.

By BERNHARD H. DAWSON.

The star *p Eridani*, DUNLOP 5, is among the best observed, and yet is one of the poorest determined of the southern binaries, and is of interest on account of the great size of the orbit. This is at the same time the chief cause of the indetermination, for the observed arc is only a little over 90° in spite of the fact that its chord is more than 9″. The curvature indicated by the observations is so small that rejecting those of DUNLOP and HERSCHEL the remainder were for a long time as well represented by the hypothesis of rectilinear motion proposed by RUSSELL as by the orbits which were computed by DOWNING and GORE. This was brought out by BURNHAM in 1893, at which time he said that the observations of the next ten years should decide whether the motion was rectilinear or binary, but that the elements of the orbit would remain indeterminate for a century. In 1912 INNES called attention to the fact that the motion could then no longer be represented by a straight line and that the star must consequently be binary.

The observations since 1900 depart as much from GORE's orbit on one side as they do from the straight line on the other, but BURNHAM's statement that the orbit would long remain indeterminate has apparently discouraged any attempt at improvement. With the approaching appearance of a second edition of INNES' *Reference Catalogue* the time seemed opportune for a new attack, especially as COMSTOCK's new method offered hope that a solution could now be made.

All the available observations were accordingly collected and the observed position angles and distances plotted with the time as argument. Smooth curves were drawn through the points and the values of the quantities read off at intervals of five years. The values so obtained were combined and plotted in polar coördinates, and the resulting points tested for the constancy of the areal velocity, which was found to be satisfied within the limits of accidental error by all the points from 1835 on. DUNLOP's observation of 1826 showed a considerable discordance and was accordingly rejected. The curve indicated by the remaining points is quite smooth and well defined. Not only is there no doubt of departure from a straight line, but it is also certain that the curvature at each end of the observed arc is greater than that at the middle. The apparent orbit is consequently quite elongated with the extremity of the minor axis near the middle of the observed arc.

The apparent ellipse was drawn by trial and the following elements were obtained from it by ZWIERS' method.

ELEMENTS I

$P =$ 218.93 years
$T =$ 1806.14
$e =$ 0.7208
$a =$ 8″.0012
$\omega =$ 301°.40
$i = \pm 114.264$
(± 65.736, angles decreasing)
$\Omega =$ 1.146 (1880.0)

Ephemerides were computed from these elements and from those by GORE. These are compared with the readings of the interpolating curves in the following table.

TABLE I. COMPARISON OF GORE'S ELEMENTS AND ELEMENTS I WITH THE INTERPOLATING CURVES

Date	Angle Gore	Angle δ_1	Angle Curve	Distance Gore	Distance δ_1	Distance Curve	Date	Angle Gore	Angle δ_1	Angle Curve	Distance Gore	Distance δ_1	Distance Curve
	°	°	°	″	″	″		°	°	°	″	″	″
1825.0	355.9	324.0	352.0	2.03	3.60	3.40	1875.0	239.0	238.7	238.6	6.11	5.85	5.88
30.0	324.0	312.4	319.0	2.60	3.60	3.52	80.0	234.8	234.6	234.4	6.41	6.23	6.26
35.0	303.9	301.0	301.8	3.16	3.64	3.65	85.0	231.0	230.9	230.8	6.69	6.61	6.57
40.0	289.5	289.9	289.2	3.65	3.73	3.80	90.0	227.4	227.7	227.4	6.96	6.98	6.99
45.0	278.4	279.6	279.0	4.07	3.90	4.00	95.0	224.1	224.8	224.4	7.22	7.35	7.37
50.0	269.2	270.3	269.8	4.46	4.13	4.22	1900.0	221.0	222.2	222.2	7.47	7.69	7.73
55.0	261.5	262.1	262.0	4.82	4.41	4.45	05.0	218.1	219.8	219.4	7.70	8.02	8.06
60.0	254.8	254.9	254.8	5.16	4.74	4.75	10.0	215.4	217.6	217.2	7.93	8.33	8.38
65.0	249.0	248.7	248.6	5.49	5.09	5.10	15.0	212.9	215.5	215.0	8.15	8.62	8.66
70.0	243.7	243.3	242.8	5.81	5.47	5.48	20.0	210.5	213.5	213.6	8.35	8.88	8.94

It is evident that the representation of the curves is better with the new elements, partly because GORE attempted to make his orbit fit DUNLOP's observation. We are now in a position to say definitely that this contains some error other than that of quadrant, and on rejecting it we obtain a better representation, not only of the observations since 1900, but also of those in the interval 1850 – 1880.

In the hope of correcting these elements still further the observations were compared individually with values interpolated from the ephemerides, and the residuals grouped into fifteen normals in angle and fourteen in distance, assigning weights according to number of nights, aperture of telescope used and experience of the observer at the time. These normal residuals are given in Table II.

TABLE II. NORMAL RESIDUALS, (O — C)

Mean Epoch	$\Delta\theta$ Gore	$\Delta\theta$ δ_1	$\frac{s\Delta\theta}{57.3}$ Gore	$\frac{s\Delta\theta}{57.3}$ δ_1	Weight	Mean Epoch	Δs Gore	Δs δ_1	Weight
	°	°	″	″			″	″	
1835.30	−1.60	+1.05	−0.089	+0.067	5	1835.00	+0.486	+0.014	2
46.35	+0.78	−0.48	+0.057	−0.033	2	46.51	+0.076	+0.307	1½
51.27	+0.53	−0.39	+0.042	−0.029	7½	51.49	−0.304	+0.054	6½
55.14	+0.59	+0.03	+0.050	+0.002	12	56.17	−0.370	+0.043	6
62.02	−0.23	−0.13	−0.021	−0.011	6	62.02	−0.438	−0.020	4
70.60	−0.86	−0.45	−0.088	−0.043	8½	70.77	−0.343	−0.015	3½
79.13	+0.03	+0.30	+0.003	+0.032	8½	79.08	−0.119	+0.073	8
87.23	+0.35	+0.22	+0.041	+0.026	9	87.16	−0.073	−0.041	8
90.95	−0.21	−0.61	−0.026	−0.075	23	90.93	+0.025	−0.019	16½
94.12	+0.30	−0.34	+0.038	−0.044	18	94.40	+0.032	−0.082	15
96.25	+0.92	+0.11	+0.117	+0.014	19	96.30	+0.255	+0.102	13
1901.02	+2.23	+0.98	+0.293	+0.133	11	1902.08	+0.303	+0.056	13
07.02	+1.49	−0.32	+0.203	−0.046	8				
13.02	+1.95	−0.45	+0.274	−0.067	15	13.02	+0.461	+0.021	15
18.55	+2.88	−0.07	+0.417	−0.011	14	18.55	+0.568	+0.056	14

[pvv]; GORE 18.31, ELEMENTS I 1.07

The partial differential coefficients of COMSTOCK's method were then computed, and it was found that the four increments $\Delta\omega$, $\Delta\phi$, $\mu\Delta T$ and $\Delta\mu$ had coefficients so similar that at least three of them would be indeterminate. This is made clear in Table III, where the values of the coefficients are given at intervals of twenty-five years.

Table III. Partial Differential Coefficients

	$\Delta\Omega$	$\Delta\omega$	Δi	$\Delta\varphi$	$\mu\Delta T$	$\Delta\mu$	Δa
	A	B	C	D	F	G	
1835	+.0635	−.1223	−.0610	−.1849	+.08754	−2.525	....
1860	+.0827	−.1883	+.0491	−.1521	+.06715	−3.617	..
1885	+.1154	−.1835	+.1262	−.0727	+.01815	−3.797	..
1910	+.1453	−.1627	+.1538	−.0113	+.03822	−3.970	..
		b	c	d	f	g	h
1835	..	−.0556	+.1055	−.0523	−.00740	+0.214	+0.4544
1860	..	+.0448	+.1693	+.0736	−.04165	+2.243	−0.5924
1885	...	+.1050	+.1492	+.0937	−.04583	+3.614	+0.8261
1910		+.1402	+.1129	+.0684	−.03627	+3.638	+1.0408

Table IV. Comparison of Observations with Elements II

Date	Angle Obs.	Angle O–C	Distance Obs.	Distance O–C	n	Obs'r
	°	°	″	″		
1826±	343.1?	[+21.5]	2½	[−1.1]	?	Dunlop
34.79	300.4	− 1.0	2¼	[−1.4]	2	h, (R)
35.00	302.3	+ 1.4	3.65	0.00	4·3	h, (E)
36.72	299.5	+ 2.5	4¼	[+0.6]	2	h, (R)
45.87	276.0	− 1.8	4.16	+0.22	2·1	Jacob
46.83	277.0	+ 1.1	4.32	+0.33	2	Jacob
49.82[1]	270.0	− 0.5	...	......	2	Jacob
50.80	268.7	0.0	4.32	+0.14	4	Jacob
50.85	268.7	0.0	4.32	+0.14	3	Maclear
51.79	266.4	− 0.7	4.30	+0.06	1	Jacob
52.76	264.8	− 0.6	4.14	−0.15	4	Jacob
53.95	263.2	− 0.4	...	....	9	Powell
53.99	263.2	− 0.2	4.36	0.00	3·2	Jacob
54.90	262.6	+ 0.5	4.44	+0.02	2	Maclear
56.09	261.1	+ 0.8	4.70	+0.21	3	Jacob
57.96	258.1	+ 0.5	4.49	−0.13	3	Jacob
61.03	253.4	0.0	4.86	+0.13	6·4	Powell
63.02	250.9	0.0	4.86	−0.10	4	Powell
70.07	243.0	− 0.1	5.64	+0.15	6·2	Powell
70.92	242.1	− 0.2	5.46	−0.09	1	Russell
71.08	241.6	− 0.5	5.46	−0.11	6·5	Powell
77.9[1]	236.0	− 0.1	6.36	+0.27	2	Ellery
78.18	236.9	+ 1.0	6.03	−0.08	3	Russell
78.80	235.0	− 0.4	6.28	+0.12	1	Russell
79.93	237.3	+ 2.8	5.44	[−0.80]	1	Hargrave
80.44	234.7	+ 0.6	6.30	+0.02	1	Russell
80.47	233.6	− 0.5	6.42	+0.13	5	Tebbutt
82.18	233.0	+ 0.2	7.01	+0.59	1	Tebbutt
85.19	230.5	− 0.2	7.10	+0.46	1	Tebbutt
86.90	230.3	+ 0.7	6.74	−0.03	2	Pollock
87.13	231.8	+ 2.4	6.90	+0.11	2	Tebbutt
87.86	229.2	+ 0.3	6.95	+0.10	4·3	Tebbutt
87.91	228.8	− 0.1	6.42	−0.43	4·3	Pollock
89.87	227.0	− 0.7	7.00	0.00	3·2	Tebbutt
89.94	227.7	0.0	7.04	+0.04	5·4	Pollock
1890.83	227.1	0.0	7.15	+0.08	2·1	Tebbutt
90.95	226.7	−0.3	6.84	−0.24	8	Sellors
91.81	226.1	−0.4	7.26	+0.12	4·4	Tebbutt
91.93	225.0	−1.4	6.87	−0.28	5	Sellors
92.87	226.3	+0.4	7.01	−0.21	3·1	Tebbutt
92.97	225.1	−0.7	6.85	−0.37	3	Sellors
93.91	224.8	−0.5	6.96	−0.33	4	Sellors
94.82	225.1	+0.3	7.34	−0.01	9·9	Tebbutt
94.96	224.0	−0.7	7.35	−0.01	3	Sellors
95.87	225.2	+1.0	7.75	+0.32	8·3	Doberck
95.94	224.0	−0.2	7.66	+0.23	3	Sellors
95.94	224.5	+0.3	7.47	+0.04	8·6	Tebbutt
96.93	223.4	−0.2	7.40	−0.10	3	Sellors
96.99	223.5	+0.1	7.61	+0.10	3	Tebbutt
1900.05	223.0	+1.0	8.12	+0.40	3	Tebbutt
00.38	223.5	+1.6	7.69	−0.05	2	Lunt
01.03	221.8	+0.3	7.80	+0.02	2	Innes
02.07	222.4	+1.4	7.67	−0.18	4	Tebbutt
06.16	219.8	+0.7	8.90	[+0.78]	4	Tebbutt
06.7	221.1	+2.2	8.6	[+0.15]	1	Hirst
07.91	216.6	−1.7	8.23	0.00	3·4	Tebbutt
08.9	217.4	−0.5	7.7	[−0.58]	1	Hirst
11.37	216.9	+0.1	8.32	−0.11	5	Innes
13.77	215.3	−0.6	8.71	+0.14	6	Dawson
13.79	215.4[2]	−0.5	8.55	−0.02	1	Hussey
13.88	216.6	+0.8	8.58	0.00	2	Innes
13.96	214.4	−1.4	8.57	−0.01	4	Voûte
17.17	214.2	−0.3	8.75	−0.01	5	Dawson
18.96[3]	213.6	−0.2	8.92	+0.07	3	Dawson
18.96[3]	214.8	+1.0	8.89	+0.04	3	Tapia
19.76[3]	214.1	+0.6	8.82	−0.07	2	Tapia
19.76[3]	213.4	−0.1	9.06	+0.17	2	Dawson

(1) Original Publication not seen.
(2) Correcting evident mistake of 10°.
(3) Hitherto unpublished.

In spite of this the normal equations were formed and an attempt was made at elimination, but this only confirmed the previous conclusion. The elimination of the three best determined quantities left no coefficient greater than 0.55, and to eliminate a fourth would have reduced all the coefficients of the remaining three to less than 0.11. This makes it evident that the problem is not yet ripe for a definitive solution, and probably will not be for many years to come. The best that can be done at present is to determine a set of elements which will represent the observations to date and furnish an ephemeris for comparison until a better solution can be made.

In view of this indetermination the only corrections applied were $\Delta\Omega = -0^\circ.116$ and $\Delta a = +0''.0238$. These are independent of each other and were computed from their respective normal equations supposing all other corrections zero. Their application reduces the $[pvv]$ of the normal places from 1.07 to 1.04. The gain is inappreciable, but so also would be that from the application of all the corrections that could be determined, for the quantity $[nn.4]$ is 0.98. Applying these corrections to Elements I, we obtain the following provisional elements:

Elements II

$P =$ 218.9 years
$T =$ 1806.14
$e =$ 0.721
$a =$ 8''.025
$\omega =$ 301°.40
$i = \pm 114.26$
$\Omega =$ 1.03 (1880)

The observations used and their residuals when compared with Elements II are given in Table IV.

While these elements are of necessity uncertain, yet they should represent the apparent motion for several years to come. An ephemeris for the interval 1920 — 1940 is accordingly given, in which an extra decimal place has been retained to facilitate accurate interpolation.

Table V. Ephemeris, 1920 — 1940

	θ	s
	°	''
1920.0	213.43	8.903
21	12.96	8.965
22	12.50	9.025
23	12.04	.084
24	11.59	.141
1925.0	211.14	9.196
26	10.70	.249
27	10.27	.300
28	09.84	.350
29	09.42	.397
1930.0	209.00	9.443
31	08.59	.486
32	08.18	.528
33	07.77	.568
34	07.36	.605
1935.0	206.95	9.640
36	06.55	.673
37	06.15	.704
38	05.76	.732
39	05.37	.758
1940.0	204.98	9.781

Note: In the computation of the differential coefficients it was noticed that if we form the constant auxiliary, $\tau = 0.01745\ a^2 \cos\phi \cos i$ we shall have, in Comstock's notation, $F = -\frac{\tau}{s}$, which is simpler than the form he gives. If the quantity F is computed by both formulas this will furnish a rigorous check on the three quantities A, B, and F. If an ephemeris has been computed for equidistant epochs, an approximate check on f (and consequently on b and c as well) may also be obtained by interpolating the first order differences to the middle and dividing the resulting quantities by the ΔM corresponding to the interval of the ephemeris.

La Plata, October, 1919.

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OBSERVATIONS OF WOLF'S PERIODIC COMET,

By E. E. Barnard.

Wolf's comet was found visually by the writer at the present return on 1918 July 11 (H. C. O. Bulletin No. 665). The discovery was promptly announced by telegraph and cabled by the Harvard College Observatory. It was closely following the ephemeris of M. Kamensky, printed in the *Astronomical Journal*, but I was unable to look for it earlier. On July 16 announcement was received in this country that it had been found on July 9 at Greenwich by Jonckheere, who gave an approximate position of it (H. C. O. Bulletin No. 666). This was our first intimation that the comet had been seen elsewhere.

It is a curious fact that a similar thing happened at the first predicted return of this comet in 1891, when it was found by the writer with the 12-inch telescope at the Lick Observatory on May 3, with the aid of an ephemeris by Berberich. The discovery was at once telegraphed (*A. N.* 3033, Bd. 127, p. 149). Afterward it was found (*A. N.* 3035, Bd. 27, p. 183) that the comet had been seen by Spitaler at Vienna with the 27-inch refractor on May 1, but announcement of his discovery had been delayed because of uncertainty.

At the present return the comet appeared most of the time to brush out into a small fan-shaped tail with a faint nucleus eccentrically placed in the nebulo ity. Throughout the apparition it very closely followed the excellent ephemeris of M. Kamensky (*A. J.*, Vol. XXXI, pp. 66, 145).

Measures of the Comet

Date	Cent. Stan. Time	Δ α cos δ	Δα	Δδ	Comps	α App.	δ App.	log pΔ α	log pΔ δ	*
1918	h m s	″	m s	′ ″		h m s	° ′ ″			
July 11	11 23 52	......	−0 33.52	−2 0.7	12*tr*,6	20 34 9.97	+24 57 52.0	9.3344*n*	0.4624	1
11	11 53 14	......	−0 32.33	+4 14.0	6*tr*,6	20 34 8.61	+24 58 3.1	9.1987*n*	0.4440	2
16	12 59 57	− 17.7	−0 1.31	+1 2.8	4 , 7	20 31 21.31	+25 41 13.3	8.3617	0.4031	3
18	12 58 11	−165.0	−0 12.23	+0 53.3	3 , 5	20 30 7.3	+25 55.9	8.6021	0.3997	4
30	8 57 1	+262.9	+0 19.64	−1 22.3	4 , 6	20 21 35.19	+26 46 1.5	9.5051*n*	0.4914	5
Aug. 1	10 55 6	+183.8	+0 13.73	−2 5.7	4 , 8	20 19 56.51	+26 47 51.9	8.9138*n*	0.3802	6
6	8 34 5	+253.4	+0 18.92	+0 9.0	4 , 6	20 16 3.26	+26 43 24.2	9.4857*n*	0.4814	7
27	8 0 24	+217.0	+0 15.84	+0 55.9	4 , 6	20 2 31.3	+23 59.5	9.2765*n*	0.4757	8
Sept. 5	10 36 21	+162.2	+0 11.64	+0 36.2	4 , 6	19 59 54.2	+21 42.8	9.2945	0.5051	9
7	10 30 23	+104.6	+0 7.47	−2 48.3	5 , 6	20 0 25.2	+21 8.3	9.2967	0.5353	10
12	11 37 46	−115.5	−0 8.19	−0 38.3	4 , 6	20 0 40.1	+19 35.1	9.5289	0.5999	11
17	9 34 49	− 8.3	−0 0.58	−1 6.0	4 , 8	20 2 16.91	+17 59 52.5	9.2201	0.5752	12
19	10 58 47	− 57.8	−0 4.04	+2 3.3	5 , 8	20 3 15.83	+17 18 21.3	9.4941	0.6274	13
21	10 44 20	+113.5	+0 7.89	+3 21.5	5 , 6	20 4 22.91	+16 37 32.9	9.4771	0.6253	14
24	7 52 47	......	....	+2 0.4	. 3	....	+15 38.4	.....	0.6493	15
24	7 56 35	+202.2	+0 13.99	......	2 .	20 6 31.2	....	9.5119	....	15
26	10 44 23	−150.6	−0 10.39	−1 10.9	5 , 6	20 7 56.67	+14 52 57.9	9.5065	0.6580	16
28	11 32 16	+ 21.0	+0 1.44	−0 15.5	4 , 7	20 9 42.08	+14 9 55.4	9.5832	0.6920	17
Oct. 3	10 20 43	+179.3	+0 12.24	+2 28.1	5 , 8	20 14 43.7	+12 24.9	9.4955	0.6812	18

Date		Cent. Stan. Time	Δ α cos δ	Δα	Δδ	Comps.	α App.	δ App.	log pΔ α	log pΔ δ	*
1918		h m s	″	m s	′ ″		h m	° ′ ″			
Oct.	5	7 29 55	−243.9	−0 16.60	−3 33.2	5 , 8	20 16 55.8	+11 45.1	8.4314	0.6513	19
	8	10 25 24	+128.7	+0 8.73	+0 23.7	5 , 8	20 20 50.4	+10 38.7	9.5145	0.6981	20
	12	7 4 18	+ 17.1	+0 1.16	−3 16.5	6 , 6	20 26 13.2	+ 9 17.1	8.1139	0.6803	21
	29	8 18 41	−178.9	−0 11.96	−0 25.0	5 , 6	20 56 36.2	+ 2 59.2	9.3304	0.7497	22
Nov.	2	7 1 53	− 24.7	−0 1.64	−0 33.2	5 , 7	21 4 55.5	+ 2 49.3	8.9638	0.7482	23
	5	6 30 11	+252.4	+0 16.84	−0 29.7	5 , 6	21 11 42.2	+ 2 1.1	8.9128	0.7551	24
	12	7 38 24	−132.3	−0 8.82	+0 34.5	5 , 8	21 27 54.76	+ 0 23 8.1	9.2695	0.7694	25
	23	6 21 53	+ 60.6	+0 4.04	+1 33.6	5 , 8	21 55 23.71	− 1 40 36.0	8.8865	0.7867	26
	26	6 26 54	+253.9	+0 16.94	−2 20.3	5 , 8	22 3 16.7	− 2 7.6	8.9823	0.7889	27
	30	6 31 55	− 99.9	−0 6.67	−2 34.6	5 , 8	22 13 56.71	− 2 39 31.7	9.0492	0.7931	28
Dec.	7	6 37 59	+ 59.0	+0 3.94	−3 2.0	5 , 6	22 33 1.64	− 3 22 42.0	9.1959	0.7980	29
	14	6 22 3	− 47.6	−0 3.18	+4 31.1	5 , 8	22 52 25.91	− 3 50 52.5	9.0969	0.8014	30
1919	17	7 25 58	+104.1	+0 6.96	+3 19.0	4 , 6	23 0 57.23	− 3 58 42.9	9.1367	0.8021	31
Jan.	18	6 29 37	−151.9	−0 10.14	−0 2.5	5 , 6	0 30 39.39	− 3 10 11.5	9.3160	0.7952	32
	25	6 30 53	+160.2	+0 10.69	−4 35.5	5 , 6	0 49 56.7	− 2 36.1	9.3766	0.7903	33
	28	6 35 3	+ 53.3	+0 3.56	−1 6.4	4 , 6	0 58 9.18	− 2 19 35.6	9.3729	0.7882	34
Feb.	1	6 53 38	+153.4	+0 10.24	−2 0.9	6 , 8	1 9 4.0	− 1 56.3	9.4346	0.7846	35
	4	6 33 2	+ 68.0*	+0 4.53	+2 22.2	5 , 6	1 17 6.94	− 1 38 23.5	9.3892	0.7832	36
	11	6 59 32	+ 93.1	+0 6.21	+1 53.9	5 , 8	1 35 54.42	− 0 53 57.6	9.4683	0.7782	37
	15	6 55 44	+149.8	+0 9.99	+3 40.6	4 , 6	1 46 29.57	− 0 27 38.3	9.4757	0.7752	38
	18	6 48 45	+ 76.9	+0 5.12	+2 1.4	5 , 6	1 54 20.8	− 0 7.6	9.4698	0.7730	39
	25	6 55 35	−196.7	−0 13.12	+1 2.2	6 , 8	2 12 36.6	+ 0 38.3	9.4997	0.7686	40
Mar.	18	7 30 49	+265.5	+0 17.72	+0 25.0	4 , 6	3 6 1.16	+ 2 54 36.6	9.5877	0.7604	41
	22	7 28 36	+175.5	+0 11.72	−1 13.1	3 , 4	3 15 56.05	+ 3 18 2.0	9.5899	0.7597	42
Apr.	1	7 33 39	−262.0	−0 17.51	−2 50.3	3 , 7	3 40 24.16	+ 4 11 47.3	9.6075	0.7581	43
	1	7 43 29	−246.8	−0 16.50	......	3 .	3 40 25.17	... .	9.6149		43

* ? if following or preceding.

Mean Places of Comparison Stars

★	α 1918.0–1919.0	δ 1918.0–1919.0	Red. to appt. α	Red. to appt. δ	Authority
	h m s	° ′ ″	s	″	
1	20 34 39.78	+24 59 41.0	+3.71	+11.7	*Berlin A.G.C.* 7825.
2	20 34 37.23	+24 53 37.4	+3.71	+11.7	*Berlin A.G.C.* 7824.
3	20 31 18.84	+25 39 57.4	+3.78	+13.1	12½—13 mag. Comp. with *Camb. (Eng.) A.G.C.* 11515
4	20 30 15.7	+25 54.8	+3.80	+13.6	12.5 mag. Compared with *B.D.* +25° 4290.
5	20 21 11.67	+26 47 7.3	+3.88	+16.5	10 mag. Compared with *Camb. (Eng.) A.G.C.* 11261.
6	20 19 38.89	+26 49 40.5	+3.89	+17.1	12 mag. Compared with *Camb. (Eng.) A.G.C.* 11222.
7	20 15 40.34	+26 42 56.9	+4.00	+18.3	12½ mag. Comp. with *Camb. (Eng.) A.G.C.* 11122.
8	20 2 11.7	+23 58.3	+3.79	+22.3	*B.D.* +23° 3892.
9	19 59 38.9	+21 41.8	+3.73	+23.3	*B.D.* +21° 4034.
10	20 0 14.0	+21 10.7	+3.70	+23.5	*B.D.* +21° 4038.
11	20 0 44.6	+19 35.3	+3.66	+24.1	10½ mag. Compared with *B.D.* +19° 4267.
12	20 2 13.85	+18 0 34.0	+3.64	+24.5	*Berlin (A) A.G.C.* 7926.
13	20 3 16.25	+17 15 53.7	+3.62	+24.3	*Berlin (A) A.G.C.* 7943.
14	20 4 11.42	+16 33 47.0	+3.60	+24.4	*Berlin (A) A.G.C.* 7954.

✶	α 1918.0–1919.0	δ 1918.0–1919.0	Red. to appt.		Authority
	h m s	° ′ ″	s	″	
15	20 6 13.6	+15 36.0	+3.61	+24.6	10 mag. Compared with *B.D.* +15° 4067.
16	20 8 3.46	+14 53 44.0	+3.60	+24.8	*Leipzig I A.G.C.* 7767.
17	20 9 37.05	+14 9 46.1	+3.59	+24.8	*Leipzig I A.G.C.* 7788.
18	20 14 27.9	+12 22.0	+3.56	+24.8	*B.D.* +12° 4279 (9.3).
19	20 17 8.9	+11 48.3	+3.55	+24.9	*B.D.* +11° 4233.
20	20 20 38.2	+10 37.9	+3.54	+24.7	*B.D.* +10° 4271.
21	20 26 13.2	+ 9 17.1	+3.55	+25.1	*B.D.* + 9° 4552.
22	20 56 36.2	+ 3 59.2	+3.56	+25.3	*B.D.* + 3° 4482.
23	21 4 53.6	+ 2 49.5	+3.54	+25.2	12½ mag. Compared with *B.D.* +2° 4308.
24	21 11 11.2	+ 2 3.0	+3.55	+25.3	14 mag. Compared with *B.D.* +1° 4451.
25	21 27 59.99	+ 0 22 8.2	+3.59	+25.4	*Nicolajew A.G.C.* 5465.
26	21 55 16.03	− 1 42 35.1	+3.64	+25.5	12 mag. Compared with *Nicolajew A.G.C.* 5543.
27	22 2 56.2	− 2 5.7	+3.63	+25.4	12 mag. Compared with *B.D.* −2° 5697.
28	22 13 59.75	− 2 37 22.5	+3.63	+25.4	*Strassburg A.G.C.* 7764.
29	22 32 54.02	− 3 20 5.3	+3.68	+25.3	13.2 mag. Compared with *Strassburg A.G.C.* 7853.
30	22 52 25.40	− 3 55 48.8	+3.69	+25.0	14 mag. Compared with *Strassburg A.G.C.* 7928.
31	23 0 46.55	− 4 2 26.9	+3.72	+25.0	*B.D.* −4° 5819. Compared with *Strassburg A.G.C.* 7970
32	0 30 48.83	− 3 10 11.6	+0.70	+ 2.6	13½ mag. Compared with *Strassburg A.G.C.* 122.
33	0 49 45.2	− 2 31.5	+0.80	+ 1.9	*B.D.* −2° 120.
34	0 58 4.80	− 2 18 30.9	+0.82	+ 1.7	12½ mag. Compared with *Strassburg A.G.C.* 234.
35	1 8 52.9	− 1 54.3	+0.87	+ 1.4	11½ — 12 mag. Compared with *B.D.* −2° 187.
36	1 17 1.57	− 1 40 46.8	+0.84	+ 1.1	10½ mag. Compared with *Strassburg A.G.C.* 302.
37	1 35 47.32	− 0 55 52.6	+0.89	+ 1.1	13½ mag. Compared with *Nicolajew A.G.C.* 333.
38	1 46 18.71	− 0 31 19.3	+0.87	+ 0.4	13 mag. Compared with *Nicolajew A.G.C.* 364.
39	1 54 14.8	− 0 9.6	+0.87	− 0.1	12½ mag. Compared with *B.D.* −0° 303.
40	2 12 48.8	+ 0 37.3	+0.87	− 0.6	*B.D.* +0° 374.
41	3 5 42.58	+ 2 54 13.7	+0.86	− 2.1	12½ mag. Compared with *Albany A.G.C.* 904.
42	3 15 43.50	+ 3 19 17.6	+0.83	− 2.5	12½ mag. Compared with *Albany A.G.C.* 967.
43	3 40 40.80	+ 4 14 40.7	+0.87	− 3.1	? mag. Compared with *Albany A.G.C.* 1101.

Measures of Comparison Stars

Date		Δα cos δ	Δα	Δδ	Comps.
		″	m s	′ ″	
1919 Nov. 1	Star 3 — *Cambridge (Eng.) A.G.C.* 11515	......	−1 18.53	+4 7.1	12*tr*, 3
1919 Nov. 4	Star 4 — *B.D.* +25° 4290	......	−1 0.27	−0 8.6	12*tr*, 3
1918 July 30	Star 5 — *Cambridge (Eng.) A.G.C.* 11261	− 72.4	−0 5.41	−3 52.6	3 , 3
1918 Aug. 1	Star 6 — *Cambridge (Eng.) A.G.C.* 11222	+191.3	+0 14.29	−2 17.4	3 , 3
1918 Aug. 6 } 1918 Sept. 19 }	Star 7 — *Cambridge (Eng.) A.G.C.* 11122	+212.2	+0 15.84	−1 7.2	5 , 6
1918 Sept. 12	Star 11 — *B.D.* +19° 4267	......	+0 41.11	+0 47.9	12*tr*, 3
1919 Nov. 4	Star 15 — *B.D.* +15° 4067	+220.6	+0 15.27	+2 15.2	3 , 3
1918 Nov. 2	Star 23 — *B.D.* +2° 4308	......	−0 53.71	−0 15.4	18*tr*, 4
1918 Nov. 5	Star 24 — *B.D.* +1° 4451	+160.0	+0 10.67	−2 47.3	4 , 4
1918 Nov. 23	Star 26 — *Nicolajew A.G.C.* 5543	+110.7	+0 7.38	+3 47.4	4 , 4
1918 Nov. 26	Star 27 — *B.D.* −2° 5697	+319.0	+0 21.32	+2 37.6	4 , 4
1918 Dec. 7	Star 29 — *Strassburg A.G.C.* 7853	......	−0 58.77	−0 39.3	12*tr*, 4
1918 Dec. 14	Star 30 — *Strassburg A.G.C.* 7928	− 54.5	−0 3.64	+2 2.9	4 , 5

Date		$\Delta\alpha \cos\delta$	$\Delta\alpha$	$\Delta\delta$	Comps.
		″	m s	′ ″	
1918 Dec. 17	Star 31 — *Strassburg A.G.C.* 7970	......	+0 21.72	+6 17.2	.....
1919 Jan. 18	Star 32 — *Strassburg A.G.C.* 122	−287.1	−0 19.17	+2 59.4	4 , 4
1919 Jan. 28	Star 34 — *Strassburg A.G.C.* 234	......	−1 42.97	+0 47.2	10*tr*, 3
1919 Feb. 1	Star 35 — *B.D.* −2° 187	......	−1 28.70	−3 0.2	6*tr*, 3
1919 Feb. 4	Star 36 — *Strassburg A.G.C.* 302	+251.8	+0 16.79	+3 21.2	3 , 3
1919 Feb. 11	Star 37 — *Nicolajew A.G.C.* 333	......	−1 26.56	−0 56.6	8*tr*, 4
1919 Nov. 15	Star 38 — *Nicolajew A.G.C.* 364	......	+0 30.10	+5 20.5	14*tr*, 6
1919 Feb. 18	Star 39 — *B.D.* −0° 303	......	−1 6.64	−0 0.8	8*tr*, 3
1919 Mar. 18	Star 41 — *Albany A.G.C.* 904	......	+0 41.34	−1 46.8	10*tr*, 2
1919 Mar. 22	Star 42 — *Albany A.G.C.* 967	......	−1 8.82	−3 48.0	8*tr*, 2
1919 Apr. 1	Star 43 — *Albany A.G.C.* 1101	−312.9	−0 20.92	+3 38.8	3 , 3

The comparison star for August 27 (No. 8) is double. It is *B.D.* +23°3892 ($9^M.5$).

		°	″	
1918.654 Aug. 27	P. A.	161.53	Dist. 0.72	10^M — 11^M
.698 Sept. 12		158.26	0.72	
1918.676		159.90	0.72	

Star 31 — *B.D.* −4°5814

B.D. −4°5814 — *Strassburg A.G.C.* 7970

This gives for the position of *B.D.* −4°5814:

1918.0 α 23ʰ 0ᵐ 20ˢ.55 δ −4° 0′ 22″.9.

Star 15 was compared also with a $9\frac{1}{2}^M$ — 10^M star north preceding. $\Delta\alpha$ 193″.1 (3), $\Delta\delta$ 77″.8 (3).

On December 17 Star 31 was compared with *B.D.* −4°5814 and this in turn was measured with *B.D.* −4°5815 = *Strassburg A.G.C.* 7970.

$\Delta\alpha$ +0ᵐ 26ˢ.00 (10 tr.) $\Delta\delta$ −2′ 4″.0 (3)

$\Delta\alpha$ −63″.98 = −0ᵐ 4ˢ.28 (4) $\Delta\delta$ −4′ 13″.2 (4)

Star No. 40 *B.D.* +0°374 ($9^M.2$) was compared directly with *B.D.* +0°375 (9.5). $\Delta\alpha$ 131″.2 (4) = 8ˢ.75, $\Delta\delta$ 53″.3 (3).

Notes on the Appearance of the Comet

1918 July 11. 14 mag. ½′ or ¼′ diameter. Almost a stellar nucleus in the following part with a brushing out of the nebulosity preceding.
16. 14 mag. ¼′ diameter. A little brighter at the following edge.
18. 14½ mag. There seemed to be a small nucleus or brightening in the following part.
30. 14 mag. Small nucleus near the north following edge.
Aug. 1. 14½ mag. ½′ diameter. Small speck in the north part.
6. 13½ mag. ½′ diameter. Condensation in the north following part.
27. 13 mag. Faint, indefinite nucleus.
Sept. 5. 13½ mag. Very small nucleus of 14 mag. A faint diffusion south following 1′, forming a fan-shaped tail.
7. 14 mag. with a faint nucleus and fan-shaped tail extending south following 1′.
12. 13 mag. with faint nucleus or condensation. The nebulosity extends south following to form a fan-shaped tail.
19. 13½ mag. Fairly well seen as a small spot 3″ — 4″ diameter. Rather faint in bad seeing and full moonlight
21. Fairly well seen but not so definite as before.
24. Observation incomplete from clouds.
26. 13 mag. Small brighter condensation in north side.
Oct. 3. 12½ mag. A condensation to almost a nucleus; short brushy tail south following.

1918	Oct.	8.	13 mag. It appeared as in previous observations.
		29.	13 mag. ¾′ diameter. Small nucleus of 13½ mag., not sharp but nearly so.
	Nov.	5.	13 mag. 1′ diameter. Strongly condensed to possibly a faint nucleus.
		12.	Somewhat condensed. Rather faint on white sky and dim from moon and bad seeing.
		23.	13½ mag. 1′ diameter. *R*. strongly condensed to possibly a 13 mag. nucleus.
		26.	1′ diameter. *R*, *mbM* to a 12½ mag. nucleus. Faintly visible in 4-inch finder.
		30.	13½ mag. 2′ diameter; strongly condensed. Perhaps feebly visible in 4-inch finder.
	Dec.	7.	1′ — 2′ diameter. *R*, *gbM*. It was perhaps larger and less strongly condensed.
		14.	Rather faint in nearly full moonlight.
		17.	Faint in moonlight and poor sky.
1919	Jan.	18.	13½ mag. 1′ — 2′ diameter; *mbM* to almost a nucleus.
		25.	13½ mag. 1½′ diameter; *mbM*.
		28.	14 mag. 1½′ diameter; *bM* to almost a nucleus.
	Feb.	1.	14 mag. 1½′ diameter; *gbM* to nearly a nucleus.
		4.	Faint, 14 mag. *R*, *gbM*.
		11.	Faint in moonlight.
		15.	Faint, 14 mag., but rather strong central brightness.
		18.	14½ — 15 mag. 1′ diameter. *R*, *vgbM*.
		25.	15 mag.
	Mar.	18.	Rather faint, 15 mag. 1′ diameter. Not very strongly condensed.
	Apr.	1.	15½ mag. ¼′ diameter. A little brighter in the middle.

Nebulæ Near the Comet

Part of the time the comet seemed to be in a region of small nebulæ, several of which were observed near it.

1919 Jan. 18. Nebula 15 mag.; 5″± diam.; *bM*. Compared with a 12 mag. star whose rough place is:

$$1855.0 \quad \alpha\ 0^h\ 28^m\ 2^s, \quad \delta\ -3^\circ\ 26'$$

Neb. − star $\Delta\alpha$ − 163″.1 (5) = − $10^s.89$, $\Delta\delta$ − 0′ 54″.4(6). Rough position of nebula:

$$1855.0 \quad \alpha\ 0^h\ 27^m\ 50^s \quad \delta\ -3^\circ\ 31'$$

1919 Jan. 28. Two nebulæ were near the comet, one in the field with it.

No. 1. 15 mag.; 3-4′ diam.; *R*, *gbM* to almost a nucleus. Measures with same comparison star as for the comet.

Neb. − star $\Delta\alpha$ − 218″.6 (3) = $-14^s.58$, $\Delta\delta$ − 3′ 48″.8 (3). Position of nebula:

$$1919.0 \quad \alpha\ 0^h\ 57^m\ 50^s.22, \quad \delta\ -2^\circ\ 22'\ 19''.7$$

No. 2. 15 mag.: ½′ diam.; *bM*. This second nebula was compared with the first one.

Neb. 2 — Neb. 1 $\Delta\alpha$ + $26^s.75$ (4 tr.), $\Delta\delta$ −1′ 15″.3 (2). This gives the position:

$$1919.0 \quad \alpha\ 0^h\ 58^m\ 16^s.97, \quad \delta\ -2^\circ\ 23'\ 35''.0$$

Yerkes Observatory, Williams Bay, Wisconsin,
1919, November 24.

OBSERVATIONS OF 70 *OPHIUCHI* = Σ 2272,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral J. A. Hoogewerff, Superintendent]

This binary is in position $\alpha = 18^h\ 0^m.4$, $\delta = +2^\circ\ 31'$ (1900). Each observation is the mean of four settings in each coördinate and is corrected for refraction. The nomenclature of the faint stars in the field is that of Burnham, Part II, p. 775.

Date	p	s	Seeing	Power	Obs.
		A and B			
	°	″			
1918.748	138.55	5.02	p	367	HL
1918.772	137.96	5.13	p	367	HL
1919.500	134.69	5.49	p	495	B
1919.577	135.23	5.43	p	388	B
1919.610	134.80	5.37	p	388	B
		A and *a*			
1918.753	228.26	38.13	f	367	HL
1919.495	228.76	37.84	p	388	B
1919.577	228.74	37.47	p	388	B
1919.744	229.07	37.08	f	495	B
		A and *b*			
1919.495	263.23	69.18	p	388	B
1919.577	263.26	68.72	p	388	B
1919.744	262.76	68.00	g	388	B
		A and *c*			
1918.758	65.10	107.24	p	367	HL
1919.500	64.95	108.02	f	495	B
1919.632	64.77	108.42	f	388	B

Date	p	s	Seeing	Power	Obs.
		A and *d*			
	°	″			
1918.767	30.76	115.98	p	367	HL
1919.500	30.68	116.41	p	495	B
1919.632	30.60	116.65	p	388	B
1919.681	30.78	116.67	p	388	B
		A and *e*			
1918.753	95.98	115.91	f	367	HL
1919.500	96.13	116.02	f	495	B
1919.681	95.96	115.92	p	388	B
		A and *f*			
1919.495	330.85	155.72	p	388	B
1919.632	330.81	156.84	f	388	B
1919.719	331.09	156.58	p	388	B
		A and *g*			
1918.769	234.44	149.74	f	367	HL
1919.495	234.47	148.91	p	388	B
1919.681	234.61	148.64	p	388	B
1919.744	234.66	148.68	f	388	B

Observers, HL = A. HALL, B = ERNEST CLARE BOWER.

Washington, D. C., 1919, Nov. 22.

ELEMENTS AND EPHEMERIS OF 1903 *NF*.

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

G. Civil T.	Astrographic α_{1900}	Astrographic δ_{1900}	$p_\alpha \rho$	$p_\delta \rho$	Largest residuals	Comparison Stars Astr. Tul	Observer	Inst.	Residuals from orbit $\cos\delta\Delta\alpha$	Residuals from orbit $\Delta\delta$
1903	h m s	° ′ ″			″				″	″
(1) Dec. 12.15331	86 27 7.7	+9 37 24.7	0.524*n*	0.645	0.8	+9.05 48, 22, 27, 30, 32, 35, 39, 44	PETERS	6-inch	+0.4	−0.1
(2) 16.19163	85 26 54.1	9 20 32.8	0.079*n*	0.636	..	....	DINWIDDIE	26-inch	−0.3	−0.8
(3) 16.21228	85 26 35.8	9 20 28.8	9.479*n*	0.635	..	....	DINWIDDIE	26-inch	+0.5	0.0
(4) 17.27067	85 10 13.1	9 16 27.9	0.373	0.642	0.7	+9.05 40, 98, 104, 106, 115, 123, 126, 131, 135	PETERS	6-inch	−0.6	+1.6
(5) 18.24274	84 56 11.0	9 12 52.6	0.122	0.639	..	....	DINWIDDIE	26-inch	−1.9	+0.4
(6) 19.28500	84 40 39.5	9 9 11.6	0.506	0.650	..	....	DINWIDDIE	26-inch	−0.2	−0.1
(7) 19.30169	84 40 26.0	+9 9 8.1	0.584	0.655	..	....	DINWIDDIE	26-inch	+1.5	−0.1

The only available observations of this asteroid have been obtained at Washington.

Observations (1) and (4) were made with a 6-inch Dallmeyer portrait lens attached to the 26-inch equatorial. The plates were measured and reduced by the writer using WILSON's Method (*Goodsell Obs. Pub.* No. 5).

The orbit by DR. A. ESTELLE GLANCY (*A. J.* **31**, 56), corrected by LEUSCHNER's method (*Lick Pub.* **7**), yields the above residuals.

ELEMENTS AND CONSTANTS FOR EQUATOR

$$\text{Epoch} = 1904 \text{ Jan. } 20.0 \text{ G. C. T.}$$

$$M = 91^\circ.53475 \qquad m_0 = 12.0$$

$$\mu = 0^\circ.2345615 \qquad g = 8.9$$

$$\log a = 0.415632$$

$$e = 0.154486$$

$$\left.\begin{aligned} i &= 12^\circ\ 45'\ 7''.3 \\ \Omega &= 221\ \ 14\ \ 28\ .4 \\ \omega &= 122\ \ 52\ \ 35\ .7 \end{aligned}\right\}\ 1900.0$$

$$\left.\begin{aligned} x &= r[9.995352] \sin (\ 73^\circ\ 24'\ 34''.9 + v) \\ y &= r[9.987567] \sin (341\ \ 21\ \ 48\ .9 + v) \\ z &= r[9.442748] \sin (\ 14\ \ \ 3\ \ 50\ .3 + v) \end{aligned}\right\}\ 1900.0$$

1902 Ephemeris (11^m.4)

G.C.T.	α_{1900}		δ_{1900}		(log r) log ρ
1902	h m		° ′		
Jun 9	19 49.8	3.8	−3 21	69	(0.374)
19	19 46.0	6.5	2 12	58	0.162
29	19 39.5	8.2	1 14	34	0.144
July 9	19 31.3	8.8	0 40	11	0.132
19	19 22.5	8.4	0 29	−12	0.126
29	19 14.1	6.9	0 41	34	0.128
Aug. 8	19 7.2	4.4	1 15	47	0.137
18	19 2.8	1.6	2 2	57	0.152
28	19 1.2	−1.5	2 59	60	0.172
Sept. 7	19 2.7		−3 59		(0.353)

1903–04 Ephemeris (12^m.1)

G.C.T.	α_{1900}		δ_{1900}		(log r) log ρ
1903	h m		° ′		
Nov. 11	6 9.0	5.2	+12 42	67	(0.408)
21	6 3.8	7.6	11 35	61	0.232
Dec. 1	5 56.2	9.4	10 34	52	0.222
11	5 46.8	9.8	9 42	39	0.218
21	5 37.0	9.3	9 3	24	0.221
1904 31	5 27.7	7.8	8 39	9	0.232
Jan. 10	5 19.9	5.4	8 30	−5	0.248
20	5 14.5	2.8	8 35	16	0.270
30	5 11.7	0.0	8 51	25	0.295
Feb. 9	5 11.7		+9 16		(0.432)

1905 Ephemeris (12^m.8)

G.C.T.	α_{1900}		δ_{1900}		(log r) log ρ
1905	h m		° ′		
Feb. 3	11 33.5	4.8	−12 42	12	(0.478)
13	11 28.7	6.6	12 30	33	0.334
23	11 22.1	7.8	11 57	53	0.320
Mar. 5	11 14.3	8.1	11 4	70	0.310
15	11 6.2	7.7	9 54	81	0.307
25	10 58.5	6.4	8 33	86	0.310
Apr. 4	10 52.1	4.6	7 7	82	0.319
14	10 47.5	2.4	5 45	73	0.332
24	10 45.1	0.1	4 32	60	0.350
May 4	10 45.0		−3 32		(0.475)

It is greatly desired that plates at other observatories be searched, especially those in the discovery opposition, 1903–04. If images are found, please communicate with this observatory.

The above is volunteer work and is unchecked.

U. S. Naval Observatory, Washington, D. C., 1919, Nov. 12.

OBSERVATIONS OF *OMICRON CETI*,

By CHARLES P. OLIVIER.

This paper forms a continuation of those in *A. J.*, No. 600 and No. 628, which contained observations of *o Ceti*. As before, all the estimates were made by Argelander's method. Generally the observations were made by the unaided eye, but sometimes an opera glass was used. It has, however, seemed useless to print the times of observations to the tenth of an hour, the number of comparison stars and the notes on the seeing, all of which were recorded in the notebooks. In most cases two comparison stars were used, but sometimes only one, and on other occasions three or more. Any uncertainty in the observations due to haze, cloud, etc., is denoted by a colon placed immediately after the deduced magnitude. The magnitudes for the comparison stars are taken as before from *Harvard Annals*, Vol. XLV.

As frequently happens with this variable, the exact dates of maxima are not very easy to determine. It would seem, however, that 1915 Jan. 10, 1915 Dec. 21±, 1916 Nov. 15, 1917 Oct. 6 and 1919 July 24± represent these dates. If we take the first and last as exact, the period comes out 332 days, practically what has long been accepted as its average value.

MAGNITUDES OF *o CETI*

Y	M	D	Magn.	Y	M	D	Magn.	Y	M	D	Magn.
1914	2	26	3.39	1915	1	13	3.80	1915	1	28	3.77
	3	2	3.31		1	14	3.82		1	29	3.77
1915	1	7	4.00		1	15	3.77		2	4	3.80
	1	9	3.72		1	20	3.77		2	8	3.82
	1	10	3.72		1	21	3.80		2	9	3.80

Y	M	D	Magn.	Y	M	D	Magn	Y	M	D	Magn.
1915	2	10	3.82	1916	12	12	3.80	1917	11	16	3.90
	11	29	3.77		12	13	3.80		11	17	3.90
	11	30	3.78		12	14	3.81		11	18	3.90
	12	2	3.78		12	15	3.81		11	22	4.00
	12	3	3.77		12	28	3.90		12	1	4.14
	12	4	3.53		12	30	3.99		12	9	4.22
	12	6	3.45	1917	1	1	4.03		12	12	4.20
	12	8	3.34:		1	11	4.44		12	13	4.20
	12	18	3.07		1	17	4.63		12	14	4.30
	12	21	3.01		1	26	5.40		1	10	5.65
	12	26	3.19:		2	3	5.42		1	13	5.56
1916	1	2	2.99		2	9	5.63	1919	7	24	3.12
	1	3	3.13		2	12	5.60		8	2	3.39
	1	4	3.13		2	16	5.62		8	3	3.46
	1	7	3.31		2	20	5.59		8	7	3.39
	1	17	3.33		9	10	4.32		8	27	3.37
	1	23	3.45		9	11	3.80		8	28	3.37
	2	4	3 86		9	12	3.81		9	11	3.64
	2	7	4.03		9	17	3.77		9	13	3.53
	2	20	5.05		9	30	3.64		9	14	3.53
	10	24	3.85		10	6	3.52		9	16	3.53
	10	25	3.80		10	7	3.68		9	25	4.13
	10	26	3.80		10	9	3.77		9	26	4.63
	10	28	3.80		10	11	3.78		9	27	4.63
	10	30	3.80		10	12	3.78		9	28	4.63
	11	1	3.80		10	14	3.77		9	30	4.63
	11	15	3.78		10	19	3.84				
	11	17	3.81		10	21	3.81				
	11	18	3.81		10	22	3.85				
	11	20	3.81		10	23	3.84				
	11	23	3.80		10	26	3.86				
	11	24	3.85		11	6	3.86				
	11	25	3.85		11	7	3.90				
	11	27	3.80		11	8	3.90				
	12	1	3.80		11	9	3.86				

Leander McCormick Observatory, University of Virginia, 1919, Nov. 25.

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70 *OPHIUCHI*; Σ 2272; *B* 8340; *P. G. C.* 4571; AND NEIGHBORING STARS.

By GEORGE C. COMSTOCK.

In 1878 HALL measured with the Washington 26-inch equatorial telescope the positions, referred to 70 *Ophiuchi*, of two faint stars which he designated as of the 13th magnitude. In 1882 and 1886 he reobserved these stars "because some astronomers doubted their existence" and added to them a third star. He designates these stars, *a*, *b* and *c*, and in the later observations he records them as of the 16th, 14th and 13th magnitudes respectively. In Vol. XII, Publications of the Washburn Observatory, I have derived proper-motion of these stars from the very limited data then available, extending only to my own observations of 1907. A considerable amount of additional material is now available and it is here utilized for a revision of these proper-motions and a redetermination of the relative masses of the components *A*, *B*, of 70 *Ophiuchi*. The proper-motions of the faint stars must depend upon an assumed proper-motion of the center of gravity of 70 *Ophiuchi* and this in turn depends upon the assumed ratio of the masses of *A* and *B*. My first intent was to adopt Boss's values of these quantities as given in the *Preliminary General Catalogue*, but partly because Boss gives no indication of the weights or probable errors with which these quantities are determined, and partly in order to utilize certain observations of later date than those used by Boss, I have rediscussed the meridian observations accessible to me, from 1754 to 1910, using Boss's systematic corrections and weights, as follows:

PROPER-MOTION OF THE CENTER OF GRAVITY OF 70 *Ophiuchi*

The data used for this determination are shown in the following Table I. In the first column of this table the symbol *Grw.* for dates subsequent to 1890 refers to the Greenwich annual volumes. The second column of the table shows the component of 70 *Ophiuchi* assumed to have been observed, *A* or *B*, and the designation *AB* here indicates an assumption that the observer did not distinguish the components but observed the star as one mass. I have reduced the resulting place to component *A* by applying as a correction one-tenth of the distance from *B* to *A* as furnished by micrometer observations. The distances and position angles required for this purpose have been read from curves in which all of the micrometer observations of 70 *Ophiuchi* known to me have been plotted against the time as argument. In Table I certain observations are marked *A* although the observer gives no indication of having seen and avoided the componen[illegible] tween *A* and [illegible] telescope emp[illegible] the two stars were seen as one.

TABLE I

Cat.	R. A. Comp.	Obs.	Epoch	Wt.	O—C	Dec. Comp.	Obs.	Epoch	Wt.	O—C
					s					″
Br. 1755	*A*	18	1754.4	0.4	+0.02	*A*	5	1755.1	0.2	+0.7
Pi. 00	*AB*	16	1800.	0.05	− .03	*AB*	13	1800.	0.15	−0.3
Dpt. 30	*A*	4	23.56	0.3	−0.02	*A*	4	23.56	1.5	−0.1
Åbo 30	*A*	12	30.	1.5	− .03	*A*	12	30.	2.5	+0.2

Cat.	R. A. Comp.	R. A. Obs.	R. A. Epoch	R. A. Wt.	R. A. O — C	Dec. Comp.	Dec. Obs.	Dec. Epoch	Dec. Wt.	Dec. O — C
					s					″
Grw. 30	*A*	13	30.	0.3	.00	*A*	10	30.	0.6	+1.5
Madras 35	*A*	9	33.54	0.25	− .05	*A*	5	31.54	0.2	+1.6
Edb. 40	*A*	3	42.00	0.1	− .03	*A*	3	42.49	0.5	0.0
Grw. 45	*A*	3	44.	0.25	− .08	*A*	4	44.	0.7	−0.5
Pulk. 55	*A*	4	44.02	1.0	− .03	*A*	4	44.02	0.5	0.0
Paris 45	*A*	70	45.7	2.5	+ .01	*A*	24	46.3	2.0	+0.1
Grw. 60	*B*	3	57.8	0.5	− .13	*B*	2	59.5	0.7	0.0
Rad. 60	*B*	7	58.0	0.4	+ .12	*B*	6	58.2	0.4	− 1.2
Rad. 60	*A*	8	58.7	0.5	+ .12	*A*	6	59.6	0.35	+0.7
Grw. 60	*A*	3	59.5	0.5	− .04	*A*	3	59.5	1.0	−0.2
Paris 60	*A*	174	60.8	2.5	− .01	*A*	151	61.0	3.0	+0.2
Wash. 60	*A*	4	64.8	0.4	− .08	*A*	4	69.6	0.35	+0.5
Wqsh. 60	*B*	4	64.8	0.4	− .06	*B*	3	70.3	0.4	−0.5
Bruss. 65	*B*	5	69.18	0.6	+ .06	*B*	5	68.16	0.7	−0.1
Glasg. 70	*A*	2	70.0	0.0	− .02	*A*	1	71.44	0.0	+2.2
Grw. 72	*A*	1	71.6	0.25	− .03	*A*	1	71.6	0.25	−0.6
Grw. 72	*B*	1	71.6	0.25	− .04	*B*	1	71.6	0.25	−0.5
Pulk. 75	*A*	6	75.1	0.6	− .05	*A*	6	75.1	0.6	+0.5
Pulk. 75	*B*	7	75.6	0.6	+ .06	*B*	7	75.6	0.6	+0.1
Paris 75	*A*	174	75.7	3.0	− .02	*A*	176	75.6	3.0	+0.3
Grw. 80	*A*	6	78.57	1.5	− .02	*A*	6	78.57	1.5	0.0
Grw. 80	*B*	4	78.61	1.0	− .01	*B*	5	78.57	1.0	−0.4
Glasg. 70	*B*	2	80.58	0.0	− .09	*B*	4	80.99	0.0	+0.1
A.G.Z. 75	*A*	4	81.12	1.0	+ .06	*A*	4	81.12	1.0	+0.2
Pulk. 85	*A*	4	87.3	0.6	+ .03	*A*	4	87.3	0.6	+0.1
Cape 85	*AB*	6	89.33	1.0	+ .03	*AB*	6	89.33	1.5	+0.2
Cinc. 90	*A*	4	90.0	0.5	+ .01	*A*	4	90.0	0.7	+0.7
Melb. 90	*A*	3	90.59	0.35	− .04	*A*	4	90.58	0.7	+0.7
Glasg. 90	*A*	2	91.42	0.0	− .04	*A*	2	91.42	0.0	+0.1
Grw. 90	*A*	8	93.06	2.0	+ .04	*A*	7	93.57	2.0	−0.6
Grw. 90	*B*	9	93.55	2.0	+ .03	*B*	7	94.15	2.0	−0.6
Grw. 90	*AB*	11	94.41	2.5	+ .04	*AB*	12	94.32	3.0	+0.5
Grw. 97	*B*	2	97.63	0.5	− .02	*B*	2	97.63	0.5	+0.7
Grw. 97	*A*	1	97.73	0.25	− .03	*A*	1	97.73	0.25	+0.1
Grw. 98	*B*	1	98.66	0.25	− .08	*B*	1	98.66	0.25	+0.4
Radc. 00	*A*	3	99.55	0.4	− .06	*A*	3	99.53	0.6	0.0
Grw. 99	*B*	2	99.62	0.5	− .02	*B*	2	99.62	0.5	0.0
Grw. 99	*A*	4	99.67	1.0	− .02	*A*	4	99.67	1.0	−0.1
Grw. 00	*A*	1	1900.79	0.25	− .04	*A*	2	1900.76	0.5	+0.6
Cinc. 00	*AB*	4	01.3	0.7	− .03	*AB*	4	01.3	0.6	−0.5
Grw. 01	*A*	5	01.64	1.5	− .06	*A*	3	01.69	1.0	−0.6
Grw. 03	*A*	1	03.83	0.25	+ .03	*A*	1	03.83	0.25	−0.1
Grw. 04	*A*	3	04.78	1.0	+ .02	*A*	3	04.78	1.0	−0.6
Madison 07	*A*	5	07.58	1.5	.00	*A*	5	07.58	1.5	−0.7
Grw. 09	*A*	3	09.70	1.0	.00	*A*	3	09.70	1.0	−0.2
Grw. 09	*B*	1	09.72	0.25	+ .03	*B*	1	09.70	0.25	−0.9

In the discussion of these observations the form of observation equation adopted, for each coördinate, is

$$x + ty + \xi k = \mathrm{O} - \mathrm{C}, \qquad (1$$

in which the coefficient t represents the time reckoned in centuries from the assumed epoch 1850.0 and ξ is the projection of the apparent distance between A and B upon the axis along which x is measured. Representing by p and s the position angle and distance of B referred to A

In R. A. $\quad \xi = s \sin p \div 15 \cos \delta$

In Dec. $\quad \xi = s \cos p.$

The unknown, k, is a measure of the relative masses of the components A, B, through the relation $k = B \div (A + B)$. The star's parallax is ignored.

Equations of the type (1) were formed for each catalogue of epoch earlier than 1830. The data furnished by the later catalogues were united into groups, the range of mean epoch of observation within each group in no case exceeding four years, and with approximate values of the coördinates and proper-motions a normal value of O — C was constructed from each group to serve as the absolute term of Equation 1. In certain cases, notably the *Paris Catalogue*, a peculiar difficulty arises in connection with the coefficient of the unknown, k. The catalogue place is based upon a large number of observations covering a considerable period of time, *e. g.* 175 observations made within a period of 13 years, during which the coefficient ξ was subject to very considerable non-linear changes. Its instantaneous value at the mean epoch of observation obviously is not the value to be associated with the published catalogue place of 70 *Ophiuchi*. I have used, therefore, a mean value of ξ for the period covered by the observations, these being assumed to be distributed with rough uniformity over the period in question. The equations thus formed furnished the following elimination equations

In R. A.

$$x + 0.265\ y - 0.126\ k = +0^{s}.063 \qquad p_x = 59.1$$
$$y + 0.567\ k = +0.130 \qquad p_y = 1.13$$
$$k = +0.515 \qquad p_k = 0.66$$

In Dec.

$$x + 0.242\ y + 0.726\ k = +2''.31 \qquad p_x = 12.53$$
$$y - 4.853\ k = +0.49 \qquad p_y = 1.69$$
$$k = +0.37 \qquad p_k = 100.58$$

The solution of these equ[illegible]
lowing a determination of [illegible]

Motions of the Faint Stars *a*, *b*, *c*

The data available for determining the motions of these stars consist of micrometer observations of their position angles and distances referred to 70 *Ophiuchi*, usually to the component A of this star. These observations are shown in the first six columns of Table II and seem to require little explanation beyond the statement that in the second column the letter C denotes my own observations, in part unpublished. In three cases, as shown in the last column of the table, it is indicated that the observation relates to the B component of 70 *Ophiuchi*. See states explicitly that his observation was so made. Hall informed me many years ago that he had no means of telling to which component of 70 *Ophiuchi* his observation of 1878 referred. I assume that it relates to B because of the gross discordances it would otherwise present.

Table II

Date	Observer	Obs.	Wt.	p	s	O — C dA	O — C [illegible]	
				Star *a*				
				° ′	″	″	″	
1878.84	Hall	3	1	49 35	87.21	−0.11	−0.26	*Ba*
82.79	Hall	2	1	47 30	92.40	+ .17	+ .29	
86.52	Hall	3	1	45 0	93.56	− .24	− .10	
89.30	β	2	1	43 12	95.17	+ .07	+ .04	
97.51	Doo.	3	0	38 7	98.68	−1.65	+ .20	
1905.60	β	4	1	35 54	105.12	+ .18	+ .15	
07.49	C	3	1	35 16	106.29	+ .15	− .03	
19.65	C	3	1	30 53	115.87	− .20	− .11	

Date	Observer	Obs.	Wt.	p	s	O — C dA	O — C dD	Remarks
				Star b				
				° ′	″	″	″	
1878.84	Hall	3	1	197 51	71.38	0.00	−0.27	Bb
82.79	Hall	2	1	197 50	65.60	+ .22	− .11	
86.53	Hall	3	1	200 24	62.50	+ .04	− .40	
89.30	β	2	1	203 18	59.45	− .47	+ .55	
99.43	Brown	1	0.5	209 43	51.95	− .02	+ .16	
99.43	See	1	0.5	208 12	50.81	− .05	+ .21	Bb
1905.54	Wirtz	9	1	213 40	47.30	+ .03	+ .17	
05.60	β	4	1	214 6	47.29	− .31	+ .32	
06.54	Wirtz	4	1	214 20	46.50	+ .11	+ .17	
07.50	C	3	1	214 17	45.87	+ .60	− .24	
07.58	Wirtz	1	0	215 29	45.73	− .10	+ .40	
10.60	Wirtz	3	1	217 35	43.25	+ 01	+ .05	
19.65	C	3	1	227 39	37.81	− .22	− .44	
				Star c				
1886.52	Hall	3	1	224 0	165.92	−0.25	−0.17	
1905.51	Wirtz	1	0.5	229 45	155.69	+ .52	− .03	
05.62	β	1	0.5	229 48	155.85	+ .31	− .04	
06.56	Wirtz	3	1	230 21	155.22	− .03	+ .53	
07.46	C	3	1	230 25	154.96	+ .15	− .01	
10.59	Wirtz	4	1	231 22	152.90	+ .09	− .09	
19.65	C	3	1	234 33	148.80	− .37	− .22	

The printed data were transformed from polar into rectangular spherical coördinates, dA and dD, referred to the point midway between A and B as origin and to the meridian of 1900,0 as axis of D. These coordinates corrected for parallax of 70 *Ophiuchi*, assumed to equal 0″.18, furnished the absolute terms of equations of the form

$$x + ty + \xi z = \text{O} - \text{C}$$

when x and y represent corrections to assumed values of the coördinates and proper-motions of the several stars, referred to the axes above defined, and $z = k - 0.5$ is a measure of the relative masses of the stars. In the equations actually employed the unit of time was 10 years and y is therefore the correction to the assumed decennial proper-motion. Least square solutions furnished the following sets of elimination equations.

In dA Star a

$$x - 0.023\ y + 1.331\ z = +0''.174 \qquad p_x = 7.00$$
$$y + 0.210\ z = +0\ .142 \qquad p_y = 15.21$$
$$z = -0\ .116 \qquad p_z = 14.60$$

In dA Star b

$$x - 0.000\ y + 0.931\ z = -0''.004 \qquad p_x = 11.04$$
$$y + 0.140\ z = +0\ .052 \qquad p_y = 26.29$$
$$z = -0\ .048 \qquad p_z = 25.96$$

In dA Star c

$$x + 0.000\ y + 1.292\ z = -0\ .003 \qquad p_x = 6.00$$
$$y + 0.932\ z = +0\ .008 \qquad p_y = 11.04$$
$$z = -0\ .276 \qquad p_z = 5.93$$

In dD Star a

$$x - 0.023\ y - 0.330\ z = -0\ .018 \qquad p_x = 7.00$$
$$y - 1.482\ z = -0\ .076 \qquad p_y = 13.87$$
$$z = -0\ .021 \qquad p_z = 4.86$$

In dD Star b

$$x - 0.001\ y - 0.903\ z = -0\ .008 \qquad p_x = 11.00$$
$$y - 1.527\ z = +0\ .092 \qquad p_y = 16.97$$
$$z = +0\ .042 \qquad p_z = 5.70$$

In dD Star c

$$x + 0.000\,y - 1.958\,z = +0.003 \qquad p_x = 6.00$$
$$y - 1.761\,z = +0.066 \qquad p_y = 5.88$$
$$z = -0.394 \qquad p_z = 1.27$$

Assembling the final equation in each of the foregoing groups and combining with them the corresponding equations furnished by the meridian observations of 70 *Ophiuchi* we obtain eight determinations of the ratio of the means of the components A B. These determinations are of very unequal weight and are expressed in divers forms, k and z. Replacing z by its value in terms of k and reducing the several equations to a common unit of weight by means of the factors shown in Table III we may obtain a homogeneous set of equations into which each determination enters with its appropriate weight. The probable errors of an equation of unit weight required for this purpose are assumed to be

for the meridian observations $r_1 = \pm 0''.30$

for the micrometric observations $r_1 = \pm 0''.19$.

The first of these values is taken from Boss, *P. G. C.* The validity of the second will be shown below.

TABLE III

		Factor	Relation
In R. A.		$(15 \cos \delta)^2\, p_k$	$148.2\,k = +\ 76.4$
Dec.		p_k	$100.6\,k = +\ 37.2$
dA	a	$(0'.30 \div 0.19)^2\, p_z$	$36.5\,k = +\ 14.0$
	b	id.	$64.9\,k = +\ 29.4$
	c	id.	$14.8\,k = +\ 3.4$
dD	a	id.	$12.1\,k = +\ 5.8$
	b	id.	$14.2\,k = +\ 7.7$
	c	id.	$3.2\,k = +\ 0.3$
			$394.5\,k = +174.2$

Since $r_1 = \pm 0''.30$ [illegible] find from their sum

$$k = [illegible]$$

which is in excellent agreement with Boss's adopted value of the same quantity $\rho = +0.45$. Adopting this value of k and the corresponding $z = -0.058$ I obtain from the several groups of elimination equations definitive values of the other quantities involved in them.

For the center of gravity of 70 *Ophiuchi* the results are summarized and compared with the data of Boss, *P. G. C.*, in Table IV.

TABLE IV

70 *Ophiuchi* Center of Gravity

	R. A. = $17^h\,57^m + x$	Dec. = $+\,2°\,32' + x$	Equinox
Epoch	1876.5	1874.2	......
x	52.643	20''.23	1850.0
Wt. Prob. Error	18.6 ±0''.07	27.7 ±0.06	
Red'n to 1900.0	+31.453	−58.62	
Seconds of R. A. and Dec.	24.096	21.61	[illegible]
Boss *P. G. C.*	24.110	21.58	
Cent. Var.	+302.820	−128''.35	1850.0
Wt. Prob. Error	1.80 ±0.22	2.24 ±0.20	......
NEWCOMB'S Precession	+301.214	− 18.57	......
Proper-Motion	+1.606 =	−109.78	......
....	+24''.07	....	......
Red'n to 1900.0	+0.53	+0.12	......
Centennial P. M.	+24.60	−109.66	1900.0
Boss *P. G. C.*	+25.33	−110.20	......

The weights here attributed to the coördinates and proper-motions differ from those shown above in connection with the elimination equations. These last named weights are those furnished by the classical formulæ for the case in which all of the unknowns are to be found from a single group of equations. In the

present case the burden of determining k or z is distributed over the eight groups of observation equations and in the most unfavorable case removes from the group in question about two-thirds of that burden and correspondingly strengthens the determination of the other unknowns. To treat k as a quantity independently known and to derive weights as if only two unknowns were involved in the equations would more nearly represent the merits of the case than do the classical formulæ and I have adopted this procedure for some of the equations that contribute very little to the determination of k. In Table IV the adopted weights are a compromise between this procedure and the classical one above suggested.

The quantities shown in Table IV furnish the following expressions for the coördinates of the A component of 70 *Ophiuchi*, in which t represents the time reckoned in centuries from the epoch 1850.0.

$$\text{R. A.} = 17^{h}\,57^{m}\,52^{s}.643 + 302^{s}.820\,t + 0.174\,t^2 - \frac{0.442}{15\cos\delta}\,s\sin p$$

$$\text{Dec.} = +2^\circ\,32'\,20''.23 - 128''.35\,t + 22''.20\,t^2 - 0.442\,s\cos p$$

Each observed place shown in Table 1 has been compared with these equations and the resulting residuals, O — C, are shown in the table.

The elimination equations arising from observations of the faint stars have been treated in a manner substantially similar to the foregoing and the results of that treatment are shown in Table V, where α represents a coördinate, in either dA or dD, referred to the center of gravity of 70 *Ophiuchi* and μ is its centennial variation. The subscript 0 refers to 70 *Ophiuchi*, the subscript 1 to the faint stars.

Table V In dA

Star	a	b	c	Equinox
Epoch	*1895.96	1899.30	1906.06	....
μ_0	24″.60	24″.60	24″.60	1900.0
$\mu_{0,1}$	−23.46	−23.40	−24.38	1900.0
Wt. P. E.	13.8 ±0″.51	17.0 ±0″.46	5.9 ±0″.78	....
μ_1	+1.14	+1.20	+0.22	....
P. E.	±0.56	±0.51	±0.81	....
α_1 at epoch	+63.73	−24.92	−119.72	1900.0
Wt. P. E.	7.0 ±0.07	11.0 ±0.06	6.0 ±0.08	....
Red'n to 1900.0	−0.95	−0.16	+1.48	....
α_1 1900.0	+62.78	−25.08	−118.24	....

Table V In dD

Star	a	b	c	Equinox
Epoch	1895.96	1899.30	1906.06	....
μ_0	−109″.66	−109″.66	−109″.66	1900.0
$\mu_{0,1}$	+106 .38	+108 .04	+109 .64	....
Wt. P. E.	13.9 ±0.51	17.0 ±0.46	5.9 ±0.78	....
μ_1	−3″.28	−1″.62	−0″.02	....
P. E.	±0.55	±0.50	±0.81	....
α_1 At epoch	+75.70	−45.23	−98.85	1900.0
Wt. P. E.	7.0 ±0.07	11.0 ±0.06	6.0 ±0.08	....
Red'n to 1900.0	+4.30	+0.76	−6.63	....
α_1 1900.0	+80.00	−44.47	−105.48	....

These results for Star a may be written in the form:

$$dA = +62''.78 + 1''.14\,\frac{T - 1900}{100} \qquad dD = +80''.00 - 3''.28\,\frac{T - 1900}{100}$$

with similar expressions for Stars b and c. The origin to which these coördinates of a refer is the position of the center of gravity of 70 *Ophiuchi* at the epoch 1900.0.

Each value of dA and dD as derived from the observed position angles and distances has been compared with the proper equation of the type last given and the resulting differences O — C are shown in Table II. From the first powers of these 50 residuals I have derived a value of the probable error of an equation of unit weight and find, without discrimination between stars or observers, $r_1 = \pm 0''.19$. In Vol. XII, Publications of the Washburn Observatory I have found from a much larger body of data $r_1 = \pm 0''.14$. The difference between these numbers appears to me a fair measure of the increased difficulty of observation due to faintness of the stars here considered. While the adopted procedure ignores real differences of precision inherent in the data it appears to me futile to attempt at this time an investigation of these differences and I have therefore adopted a single value of r_1 for the determination of weights and probable errors and I use this determination of r_1 to justify the relative weights assumed in determining the value of k.

The probable errors attached to the six values of μ_1 shown in Table V seem to me to furnish some indication of the credence that should be given to those results. All of these motions are small, as was to be expected, and the motion of the star c may be indistinguishable from 0. On the other hand, the motions of a and b differ from 0 by appreciable quantities amounting to several times the probable errors of their determination. A similar conclusion may be drawn with respect to the contribution made by these observations to the determination of the mass ratio k. I call to the attention of astronomers that the precision of all these results may be rapidly increased by further observations of the faint stars, either with the micrometer or photographically. These observations should be repeated at intervals of about a decade and it is not probable that I can myself continue them.

Summary of Results

1. Eight nearly independent determinations of the mass ratio of the components of 70 *Ophiuchi* give

$$\frac{\mathrm{B}}{\mathrm{A}+\mathrm{B}} = +0.442 \pm 0.015$$

With an adopted parallax of $0''.18$, a periodic time of 87.5 years and a major axis of $4''.5$, the combi[illegible] of the components is $A + B = 2.04$ times that [illegible] *Sun*. Whence $A = 1.14$, $B = 0.90$ and B/A [illegible]

2. The thirteenth magnitude stars a and b possess sensible proper-motions amounting to about $3''$ per century. The objection sometimes made to these and other similar results, that they are only a reproduction of errors inherent in the assumed proper-motion of the comparison star, *e. g.* 70 *Ophiuchi*, cannot hold good here because of the diversity in the results for a, b and c. No possible assumption with regard to 70 *Ophiuchi* will reconcile these diversities. They must be due either to real motions of the stars or to error in the observations. If such error be present it must far exceed in amount the measure of precision indicated by the internal agreement of the data and it must affect, in a manner approximating to uniform progression with lapse of time, the observations made by a considerable number of astronomers working under widely different conditions. This postulate appears to me much less probable than the conclusion above drawn, *viz.*, the existence of sensible proper-motions in the stars themselves.

Washburn Observatory, December, 1919.

OBSERVATIONS OF *ACHILLES* (588),

By E. E. Barnard.

The following observations of *Achilles* (588) were made at the request of Professor Stromgren. For previous observations see *A. N.* 4206, Bd. 176, p. 89 and 4641, Bd. 194, p. 171. Following are the estimations of magnitude.

April	1	$14\frac{1}{2}^{M} - 15^{M}$	
	22	$15^{M} - 15\frac{1}{2}^{M}$	Very faint in poor sky.
	26	$14\frac{1}{2}^{M} - 15^{M}$	
May	1	$15^{M} - 15\frac{1}{2}^{M}$	1st set.
	1	$15\frac{1}{2}^{M} - 16^{M}$	2d set.

These magnitudes are necessarily rough, as the conditions were not good for any magnitude estimations.

Star No. 4 was kindly observed by Professor R. H. Tucker with the Meridian Circle of the Lick Observatory. It is *B. D.* $-4^\circ 3067$ ($9^{M}.7$). His observations are:

Epoch of obs.	Mag.	α 1919.0	δ 1919.0	Obs.
1919.34	10	$11^h\,20^m\,33^s.67$	$-5^\circ\,5'\,57''.7$	(2)

Measures of the Asteroid

Date	Cen. Stan. Time	Δα cos δ	Δα	Δδ	Comps.	α App.	δ App.	log pΔ α	log pΔ δ	★
1919	h m s	″	m s	′ ″		h m s	° ′ ″			
Apr. 1	9 17 32	− 92.1	−0 6.17	−0 31.5	5, 10	11 29 27.29	−6 6 13.6	9.2624*n*	0.8176	1
1	12 51 16	−154.2	−0 10.34	−0 7.5	4, 8	11 29 23.12	−6 5 49.6	9.3579	0.8122	1
17	11 21 36	+ 39.8	+0 2.68	+1 16.3	4, 8	11 22 58.75	−5 24 11.7	9.2833	0.8089	2
22	9 24 51	+ 82.5	+0 5.52	−1 30.1	4, 8	11 21 28.61	−5 12 42.1	8.2787	0.8122	3
24	11 47 42	+274.3	+0 18.34	−1 48.7	4, 6	11 20 54.78	−5 8 7.0	9.4487	0.8021	4
26	8 52 6	−139.7	−0 9.35	+2 10.3	4, 6	11 20 27.07	−5 4 7.9	8.1139*n*	0.8116	4
26	9 13 23	−142.2	−0 9.52	+2 11.8	5, 6	11 20 26.90	−5 4 6.4	8.4314	0.8116	4
26	9 27 27	−145.2	−0 9.72	+2 12.4	4, 7	11 20 26.70	−5 4 5.8	8.7404	0.8110	4
May 1	10 21 50	+279.4	+0 18.69	−0 15.5	6, 8	11 19 23.73	−4 54 21.0	9.2810	0.8062	5
1	10 40 24	+277.6	+0 18.57	−0 14.5	6, 7	11 19 23.61	−4 54 20.0	9.3463	0.8048	5

Mean Places of Comparison Stars

★	α 1919.0	δ 1919.0	Red. to. Appt. α	Red. to. Appt. δ	Authority
	h m s	° ′ ″	s	″	
1	11 29 30.55	−6 5 21.8	+2.91	−20.3	*Strassburg A.G.C.* 4345.
2	11 22 53.26	−5 25 7.5	+2.81	−20.5	13 mag. Compared with *Strassburg A.G.C.* 4305.
3	11 21 20.26	−5 10 51.4	+2.83	−20.6	13½ mag. Compared with *B.D.* −4° 3067.
4	11 20 33.67	−5 5 57.7	+2.77 +2.75	−20.6 −20.5	*B.D.* −4° 3067. R. H. Tucker, L.O.M.C.
5	11 19 2.34	−4 53 45.1	+2.70	−20.4	*Strassburg A.G.C.* 4296.

Measures of Comparison Stars

Date		Δ α cos δ	Δ α	Δ δ	Comps.
		″	m s	′ ″	
1919 Apr. 17 22	12½ mag. star — *Strassburg A.G.C.* 4345	......	+1 35.33	+0 5.2	12 *tr*, 4
17	Star 2 — 12½ mag. star	+150.7	+0 10.09	+0 12.7	4 , 4
22	Star 3 — *B.D.* −4°3067	....	+0 46.59	−4 53.7	8 *tr*, 4

The measures give for the position of the 12½ mag. star:

1919.0 α $11^h\ 22^m\ 43^s.17$ δ − 5° 25′ 20″.2

Yerkes Observatory, Williams Bay, Wisconsin,
1919, November 24.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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NOTE ON THE ORBIT OF γ *CENTAURI*, *h* 4539,

By BERNHARD H. DAWSON.

The binary γ *Centauri* was first observed as a double star by Sir John Herschel at the Cape of Good Hope in 1835, and has subsequently been observed by almost every southern double star observer, the observations being practically continuous since 1870. Several "determinations" of the orbit have been made, with the results given in the following table.

Computer	Date	P	T	e	a	Ω	i	ω	Published
					″	°	°	°	
Gore	1892	61.88	1840.81	0.6316*n*	1.50	177.95	±95.9	46.81	*M. N. R. A. S.* 52 : 505
See	1895	88.0	1848.0	0.800	1.023	4.6	117.85	194.3	*A. N.* 3339
Doberck	1905	152.30	1835.44	0.3024	1.346	1.50	101.95	223.28	*A. N.* 4063
Doberck	1905	211.93	1851.63	0.2958	1.924	3.35	98.22	285.03	*A. N.* 4063

An essential difference between the first two orbits and the others lies in the interpretation of Herschel's observations. Innes pointed out in 1904 that, owing to the equality of the components, the quadrant is indeterminate, and Herschel's observations admitted of two interpretations: first, as used by Gore and See, that the quadrant at Herschel's time was the same as in recent years; and second, that the quadrant in 1835 was the opposite of that at present. Doberck used this suggestion in obtaining his orbits given above.

In order to test these two hypotheses by the new observations they were compared with See's orbit and with the second orbit of Doberck. The representation by the orbits as they stand is not very good in either case, but on plotting the new observations it was found that they continue to follow the curve of Doberck's apparent ellipse, indicating that his *geometrical* elements are probably substantially correct.

In computing his orbit, See rejected all of Herschel's observations with the refractor (ten nights) in favor of those with the reflector (one measure and two estimates), because he could not reconcile the angle of the former with the areal velocity shown by the modern measures. Recent measures only aggravate the difficulty. It is now over ten years since the companion passed Herschel's angle, and the motion is still relatively slow, yet it was less than twenty years after Herschel's observations that Maclear observed the companion in 22°.9, a change of over 300°. Moreover, the distance in 350° is well over 1″, while Herschel's estimates are from 2-3″ to 1″. Even with his well known systematic error of distance estimates (which is less marked in bright pairs such as this) they still indicate that the distance at his time was not over 1″.

With this new evidence the first hypothesis becomes untenable. Consequently See's elements are not even qualitatively correct, though he stated that his period and eccentricity could not be expected to need changes greater than 3 y. and 0.03, respectively. Though Innes has not to my knowledge attempted an orbit determination, yet to him is due the credit for indicating the correct solution of the problem.

But while the correct interpretation of Herschel's measures is now defined, and the motion qualitatively determined, there remains a wide range of possibility in the numerical values of certain elements. The observed arc of the apparent ellipse shows it to be much elongated, with the major axis closely north-and-south, and the star not far from the centre. We may consequently feel sure that the inclination is high, the eccentricity rather small, and the nodal point near 0°. On the other hand, we have no obser-

vations other than HERSCHEL's in the entire southern half of the ellipse, whose length is consequently indeterminate, and must remain so for a considerable time to come. Any change of this length will produce a proportional change in the values of P and a, and, owing to the nearly central position of the principal star, a much greater change in the elements ω and T.

In view of this indetermination I have been content to retain the apparent ellipse and geometric elements of DOBERCK's second orbit, making slight modifications of the dynamical elements to improve the representation of recent measures. The resulting system is:

$$
\begin{aligned}
P &= 203.39 \quad (\mu = 1^\circ.7700)\\
T &= 1851.50\\
e &= 0.2958\\
a &= 1''.924\\
\Omega &= 3^\circ.35\\
i &= \pm 98.22 \quad (81^\circ 78,\ \text{retrograde})\\
\omega &= 285.03
\end{aligned}
$$

In the comparison with observations, the systematic corrections of $+0''.20$ for SELLORS and $-0''.15$ for TEBBUTT, indicated by DOBERCK, have been applied to the observed distances.

EPHEMERIS

1900+	θ	ρ	1900+	θ	ρ
	°	″		°	″
20.5	341.38	0.836	30.5	319.08	0.488
21.5	340.04	0.800	31.5	315.10	0.459
22.5	338.58	0.763	32.5	310.61	0.433
23.5	336.97	0.726	33.5	305.55	0.409
24.5	335.19	0.690	34.5	299.90	0.388
25.5	333.21	0.654	35.5	293.70	0.372
26.5	331.00	0.619	36.5	287.01	0.360
27.5	328.54	0.585	37.5	279.95	0.353
28.5	325.77	0.552	38.5	272.72	0.351
29.5	322.63	0.519	39.5	265.53	0.355
30.5	319.08	0.488	40.5	258.57	0.364

COMPARISON WITH OBSERVATIONS

Date	θ_o	ρ_o*	O—C $\Delta\theta$	O—C $\Delta\rho$	Nights	Observer
	°	″	°	″		
1835.80	173.4	0.8 ±	+1.4	−0.1 ±	11.4	HERSCHEL
52.60	22.9	0.3 ±	−3.2	−0.2 ±	3	MACLEAR
56.20	20.6	0.7 ±	+3.8	0.0 ±	3	JACOB
57.97	13.7	1.11	−0.4	+0.27	5.2	JACOB
60.68	12.8		+1.5		10	POWELL
70.23	6.8	1.4 ±	+1.1	−0.1 ±	6	POWELL
71.06	6.2	..	−0.8	..	5	POWELL
71.39	3.8	1.18	−1.4	−0.32	1	RUSSELL
73.37	4.2	2.29	−0.3	[+0.73]	1	RUSSELL
74.26	1.6	1.61	−2.6	+0.03	1	RUSSELL
76.63	8.5	1.30	+5.1	−0.33		ELLERY
80.44	1.3	1.39	−0.8	−0.29	1	RUSSELL
82.22	2.1	2 ±	+0.5	..	1	TEBBUTT
87.53	358.5	1.60	−1.4	+0.06	5.4	POLLOCK
87.58	359.0	1.61	−0.9	−0.08	2.1	TEBBUTT
88.39	359.5	1.68	−0.1	0.00	4.5	TEBBUTT
89.32	359.1	1.73	−0.2	+0.05	4	POLLOCK
90.36	358.9	1.69	−0.1	+0.02	1	TEBBUTT
90.36	361.2	2.01	+2.2	+0.34	1	SELLORS
91.40	357.0	1.53	−1.6	−0.12	1	SELLORS
92.33	357.3	1.41	+1.0	−0.23	5	SELLORS
92.48	358.7	1.50	+0.4	−0.14	7.8	TEBBUTT
93.36	356.7	1.60	−1.3	−0.03	3	SELLORS
94.10	356.6	1.44	−1.0	−0.17	3	SELLORS
95.33	356.4	1.60	−0.9	+0.01	9.7	TEBBUTT
95.41	359.0	1.62	+1.7	+0.03	3	SELLORS
96.33	358.0	1.59	+1.0	+0.02	3	TEBBUTT
96.45	356.4	1.94	−0.5	+0.37	3	SELLORS

Date	θ_0	ρ_0*	O – C $\Delta\theta$	O – C $\Delta\rho$	Nights	Observer
	°	″	°	″		
1899.33	356.8	1.45	+1.0	−0.06	2	Tebbutt
1900.30	358.0	1.52	+2.5	+0.03	5	Tebbutt
00.49	357.3	1.49	+1.9	+0.01	3.2	Innes
01.73	355.1	1.40	+0.2	−0.05	2	Innes
02.36	355.7	1.54	+1.1	+0.11	2	Innes
02.39	354.8	1.74	+0.2	+0.31	11	Tebbutt
03.22	353.6	1.42	−0.6	+0.01	3	Innes
05.35	354.8	1.36	+1.6	+0.01		Doberck
05.47	352.9	1.37	−0.2	+0.02	8.6	Tebbutt
07.67	353.2	1.27	+1.2	−0.01	5.2	Tebbutt
09.73	352.5	1.22	+1.7	+0.01	5.4	Tebbutt
11.11	349.7	0.99	−0.2	−0.18	4	Innes
13.45	348.6	1.42	+0.3	[+0.33]	7.8	Dawson
13.48	348.1	1.13	−0.2	+0.04	2	Innes
15.34	345.0	1.16	−1.8	+0.14	4	Voûte
16.46	345.5	1.00	−0.3	+0.02	4	Innes
17.20	345.4	0.97	+0.3	+0.01	3	Dawson
18.40	344.5	0.95	+0.6	+0.04	3	Dawson
1919.31	341.8	0.76	−1.0	−0.12	3	Dawson

*Corrected for systematic error as noted above.

La Plata, November, 1919.

THE PARALLAX OF *CAPELLA* AND ITS DISTANT COMPANION,

By ZACCHEUS DANIEL and FRANK SCHLESINGER

Between February 1915 and February 1919, fifteen plates of *Capella* ($5^h\,9^m$, $+45°\,54'$) were secured here. As the star is very bright its image on our plates cannot be reduced to equality with those of the comparison stars by means of a rotating sector alone. For the first three plates the grating described by one of us (on page 15, volume 4, Publications of the Allegheny Observatory) was used. The remaining twelve plates were obtained with a small and very thin absorbing screen, close to the photographic film and immediately in front of that portion of the plate upon which the image of *Capella* is formed. This device will be described in full detail later.

The fifteen plates were measured by Mr. Daniel and yield for the relative parallax of *Capella*

$$+''.049 \quad \pm''.007,$$

and for the relative proper-motion

$$+''.078 \quad \pm''.004.$$

The distant companion to *Capella*, discovered by Furuhjelm, (*Astronomische Nachrichten* 4715), appears on the same plates, $7'\,31''$ following and $9'\,25''$ south. Five comparison stars were selected, three of which had likewise been used for *Capella* itself. Their measurement yields for the relative parallax of the companion,

$$+''.079 \quad \pm''.008$$

and for the relative proper-motion,

$$+''.068 \quad \pm''.005.$$

The average distance of the five comparison stars from the companion is $13'$. There is always danger of error in measuring the position of a star not at or near the center of the plates, unless the comparison stars are close. For this reason a second solution was made for the companion, using in effect a single comparison star distant only $35''$. This gave for the parallax

$$+''.067 \quad \pm''.009,$$

and for the proper-motion

$$+''.077 \quad \pm''.005,$$

and these are probably more reliable than those that result from the use of the five comparison stars.

Assuming that the parallaxes of *Capella* and the companion are the same, the best mean that these plates yield may be taken as

$$+''.063 \quad \pm''.006.$$

Allowing ''.005 for the parallaxes of the comparison stars, the corresponding absolute parallax is +''.068. Among earlier determinations are ELKIN's (+''.079 ±''.021), ADAMS and JOY's (+''.105), and JOST's (+''.051 ±''.023). The mean of all gives for the absolute parallax +''.077.

Capella is a spectroscopic binary with a period of 104 days. The two components do not differ very greatly in brightness. Their separation is about 83,000,000 km times the cosecant of the (unknown) angle of inclination of the orbit; it is therefore at least 0.56 of that between the *Earth* and the *Sun*. At certain times the components of this spectroscopic binary must appear to be at least 0''.04 apart. Attempts have been made by HUSSEY, AITKEN, and others to observe an elongation in the image of *Capella*, but without success.

Allegheny Observatory of the University of Pittsburgh, January 14, 1920.

OBSERVATIONS OF VARIABLE STARS,

BY WILLIAM DOBERCK.

(Continued from *A. J.* 760.)

SZ Cygni: The M. C. comparison stars were used: *c* 8.06, *d* 8.17, *d'* (*A. S. V.* 27) 8.63, *e* 8.72, *f* 8.74, *g* 9.21, *h* 9.54, *k* 0358 9.32 (7), 0633 9.48 (4), 0771 9.73 (6), 0797 9.70 (5), 1852 9.77 (6), 1920 9.82 (5), 2102 9.62 (3), 2121 9.66 (6), 2181 9.49 (5), 2241 9.71 (5), 2299 9.53 (5), *l* 10.40. *c* and *l* were determined at H. C., the others compared here. The value of a step is 0.10. The first maximum (8.64) occurred at 2421835.8, the second (8.67) at 1836.9, and the third (9.59) at 1845.1. The first minimum (8.83) occurred at 2421836.4, the second (9.61) at 1844.4, and the third (9.63) at 1846.3. The period, obtained by comparison with the value adopted by HARTWIG in 1913, and taking the mean of the first two maxima and the first minimum given above (1836.37) to represent the epoch of the present maximum, is 15.1105 days. Minimum occurs 8.9 days after maximum. *SZ Cygni* is a flash star and, like in the case of *VY Cygni*, the flash is double. The 24 equidistant coördinates of the lightcurve, beginning with 1836.37 are as follows: 8.82, 8.70, 8.94, 9.01, 9.05, 9.11, 9.20, 9.29, 9.35, 9.37, 9.46, 9.54, 9.60, 9.62, 9.59, 9.61, 9.63, 9.53, 9.41, 9.40, 9.36, 9.21, 8.78, 8.65. The curve is wavy and as the waves appear in the mean of a number of years' observations, it is evident that they are more or less repeated in every period. The formula is:

$$\begin{aligned}\text{Mag.} = 9.26 &- 0.405 \cos(x - 18\tfrac{1}{2}^\circ)\\ &-0.10 \quad \cos(2x + 11\tfrac{1}{2}^\circ)\\ &-0.06 \quad \cos(3x + 18\tfrac{1}{2}^\circ)\end{aligned}$$

It is preferable to use cos, as the dis-symmetry of the curve is then seen at a glance. The coefficients $a_4 \ldots a_{12}$ of the cos are: −0.03, −0.01, +0.04, +0.03, +0.02, +0.03, +0.02, +0.02, 0.00. The coefficients $b_4 \ldots b_{11}$ of the sin are: +0.04, +0.05, 0.00, −0.01, −0.01, −0.02, −0.01, −0.01. When a series converges so slowly it is not very important.

0347.41	*k* 1 *v* 1 *h*	9.43	0401.43	*f* 1½ *v*	8.89	0696.44	*h* 1½ *v*	.69	0779.26	*d'* 3 *v* 3 *g*	.92
0349.37	*v* = *h*	.54	0401.45	*f* 1 *v* 3 *g*	.86	0709.43	*g* 1 *v* 2 *h*	.32	0779.29	*f* 2 *v* 3 *g*	.93
0356.36	*v* = *g*	.21	0401.46	*f* 1 *v*	.84	0749.33	*e* 2 *v* 1 *f*	8.74	0779.36	*f* 1½ *v* 4 *g*	.86
0357.35	*c* 2 *v* 2 *g*	8.97	0516.22	*h* 1 *v*	9.64	0750.38	*f* 2½ *v* 1 *g*	9.08	0785.39	*v* = *k*	9.77
0358.34	*e* 2½ *v* 2 *k*	9.05	0538.25	*g* 2 *v* 4 *h*	.32	0751.39	*f* 3 *v* 2 *g*	.02	0788.36	*h* 2 *v* = *k*	.72
0361.34	*v* = *k*	.32	0646.39	*f* 3 *v* 1 *g*	.09	0752.31	*g* 3 *v* 3 *h*	.37	0789.39	*h* 1 *v*	.64
0362.34	*k* 2 *v* 1 *h*	.47	0654.45	*g* 3 *v* 3 *h*	.37	0753.34	*g* 1½ *v* 1 *k*	.50	0791.28	*v* 2½ *h*	.29
0364.36	*v* = *h*	.54	0655.44	*g* 2 *v* 2 *k*	.34	0758.48	*k* 1 *v* 4 *l*	.85	0800.35	*v* = *h*	.54
0366.35	*g* 2 *v* 2 *h*	.37	0656.45	*d* 3 *v* 3 *e*	8.44	0760.32	*g* 1 *v* 1 *h*	9.38	0801.28	*h* 2 *v* 1 *k*	.65
0368.33	*k* 1½ *v* 1 *h*	.45	0663.40	*g* 2 *v* 1 *h*	9.43	0761.31	*g* 3 *v* 3 *h*	.38	0804.36	*h* 3 *v* 1 *k*	.67
0386.41	*c* 4 *v* 2 *e*	8.50	0665.40	*g* 1 *v* 2 *h*	.32	0770.35	*h* 2 *v* 3 *k*	.62	0807.30	*v* = *f*	8.74
0401.41	*v* 3 $\frac{g+h}{2}$	9.07	0667.42	*h* 1 *v*	.64	0775.41	*v* = *h*	.54	0887.22	*g* 1 *v* 4 *h*	9.28
0401.41	*f* 3 *v*	.04	0670.40	*g* 2 *v* 1 *h*	.43	0777.36	*f* 2 *v* 3 *g*	8.93	0903.24	*v* 1 *g*	.11

1036.42	e 1½ v	8.87	1770.48	h 1 v	.64	1944.30	f 3 v 1 g	.09	2192.36	k 2½ v	.74
1036.52	f 1 v 2 e	.73	1777.45	f 2 v 3 g	8.93	1951.33	h 3 v 1 k	.70	2193.34	v = h	.54
1067.38	e 3 v 2 g	9.01	1778.49	f 3 v 1 g	9.09	1961.22	v = h	9.51	2198.39	v 1½ e	8.57
1096.38	d 4 v 3 e	8.53	1781.40	f 3 v 1 g	.09	1970.21	g 1 v 1 h	.37	2210.38	g 2 v 1 h	9.13
1125.36	d 2 v 2 e	.44	1783.43	v = h	.54	2093.45	f 1 v 2 g	8.90	2211.32	g 2 v 1 h	.43
1156.46	v 1 e	.62	1784.41	v 1 h	.41	2096.46	g 1 v	9.31	2212.32	g 1 v 2 h	.32
1157.41	e 1 v 2 f	.72	1787.42	g 1 v 1 h	.37	2098.45	g 1 v 1 h	.38	2213.31	e 3 v 2 f	8.71
1158.38	f 4 v 2 g	9.05	1793.46	g 1 v 3 h	.29	2099.48	h 1 v 3 k	.56	2214.33	e 1 v 1 f	.73
1188.44	f 4 v 1 g	.11	1796.44	g 1 v 2 h	.32	2100.45	v = k	.62	2218.37	v 1 g	9.11
1202.22	f 2 v 4 g	8.90	1812.38	g 1½ v 2 h	9.28	2101.44	h 1 v 2 k	.57	2219.32	g ½ v 3 h	.26
1202.26	f 1 v 4 g	.83	1820.41	f 2 v 1½ g	.00	2102.45	k 1 v	.72	2223.44	h 1 v	9.64
1202.37	d 2 v 3 e	.39	1826.34	g 1½ v 1½ h	.37	2107.11	f 3 v 1 g	8.95	2230.28	f 1½ v 1 g	8.86
1202.40	e 1 v 5 g	.80	1827.34	h 1 v 2 k	.62	2113.42	v ½ g	9.16	2230.42	e 1 v	.73
1217.27	d 3 v 2 d′	.45	1828.33	h 2½ v 2 k	.59	2115.44	g ½ v 1½ h	.29	2231.39	f 1 v	.84
1391.43	v = h	9.54	1830.33	v = k	.77	2117.44	g 2 v 1 h	.43	2232.27	e 3 v 2 g	9.02
1476.33	f 1 v 3 g	8.86	1838.32	f 3 v 1 g	.09	2118.41	v = h	.54	2234.39	g ½ v	.26
1503.30	v = e	8.72	1843.30	v = h	.54	2119.41	g ½ v 1 h	.32	2242.26	e 3 v 1 g	.09
1508.29	f 3 v 2 g	9.01	1844.38	k 1 v	.87	2120.40	g 2 v 1 h	.43	2244.41	e 1 v 2½ g	8.86
1521.36	f 4 v 3 g	.00	1845.33	v = h	.54	2121.43	v = g	.21	2245.26	f 2 v 1 e	.73
1527.30	g 2 v 1 h	.43	1847.30	g 3 v 1 h	.46	2123.44	f 3½ v 2 g	.12	2247.26	e 2 v 2 h	9.13
1532.42	f 2 v 3 g	8.93	1852.34	f 1 v 3 g	8.86	2124.39	e 2 v 1 f	8.74	2249.25	g 1 v 2 h	.32
1540.38	g 2 v 1½ h	9.47	1856.31	g 1 v 2 h	9.32	2124.40	f 2 v 2 g	.97	2250.25	g 1 v 1½ h	.34
1548.38	v = f	8.74	1860.33	h 3 v ½ k	.74	2124.45	f 1 v 2 g	.90	2251.25	h 1 v 3 k	.58
1549.32	e 2 v 1 f	.74	1862.29	g 2 v 2 h	.37	2124.50	f 2 v 1 g	9.05	2253.25	h 2 v 1 k	.64
1558.32	v = h	9.54	1864.37	f 3 v 2 g	.02	2125.43	f 3 v 2 g	9.02	2254.25	v ½ h	.19
1565.36	f 1 v 4 g	8.83	1865.30	v = f	8.74	2126.42	f 3 v 2 g	.02	2258.25	e 3 v 3 f	8.73
1566.36	f 3 v 2 g	9.02	1867.41	f 3 v ½ g	9.14	2127.42	v ½ g	.16	2258.40	e ½ v	.77
1568.32	g 2½ v 3 h	.45	1870.33	g 1 v 2 h	.32	2128.42	g 1 v 2 h	9.32	2274.22	f 3 v 1½ e	.73
1576.27	g 1 v 3 h	.29	1873.28	v = k	.78	2131.44	v ½ h	.49	2278.29	e 3 v 2 g	9.01
1727.49	g 1 v 1 h	.37	1874.42	h 1 v 1 k	.66	2136.45	g 1½ v 1 h	.41	2281.26	v = k	.63
1730.45	f 1 v 3 g	8.86	1875.28	h 1 v 2 k	.63	2155.39	e = v	8.72	2282.26	v = k	.63
1732.47	f 3 v 2 g	9.01	1879.47	v 1 h	.44	2176.36	v 2 h	9.34	2286.25	g 1 v 1 h	.37
1734.43	v = g	.21	1880.28	e 3 v 2 f	.74	2177.38	v 1 h	.44	2287.24	g 1 v 1½ h	.31
1741.44	v 1 g	.11	1901.47	h 1 v 1 k	.67	2178.38	k 1 v ½ h	.52	2288.23	f 1½ v 1 e	8.73
1743.47	v 2 g	.01	1906.36	h 3 v 1 k	.74	2180.38	g 2 v 1 h	.43	2292.39	e 1 v 3 g	8.84
1744.44	f 2 v 4 g	8.90	1907.38	h 1 v 1 k	.67	2182.36	f 3 v 3 g	8.97	2294.41	g 2 v 2 h	9.37
1745.45	d 3 v 2 e	.50	1913.36	f 4 v 3 g	.00	2184.41	v 1½ e	.57	2295.29	v = k	.54
1746.41	f 3 v 2 g	9.01	1919.32	k 1 v	.92	2184.50	e 1 v	.82	2300.25	h 1 v 1 k	.54
1760.42	f 1 v	8.84	1920.31	v = k	.82	2186.35	f 3 v 2 g	9.02	2302.23	v 1 h	.44
1767.48	g 2 v 1½ h	9.47	1925.33	f 3 v 1 g	.09	2187.34	g 1 v	.31	2312.20	h 1 v	.64
1768.42	v 1½ h	.39	1935.27	g 2 v 1 h	.43	2191.38	h 1 v	.64			

Kowloon, Elgin Road, Sutton, Surrey,
6 January, 1920.

OBSERVATION OF THE ECLIPSE OF THE *SUN*, NOV. 22, 1919,

BY F. P. LEAVENWORTH.

Time of Fourth Contact $3^h\ 0^m\ 10^s$ G. M. T.

Limb of *Sun* very wavy.

Minneapolis, Minn., January 20, 1920.

OBSERVATIONS OF COMET d 1919 (*FINLAY–SASAKI*),

MADE WITH THE $10\frac{1}{2}$-INCH EQUATORIAL OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

Date 1919	Minn. M.T. h m s	Comp.	☌—★ m s	″	App. α h m s	App. δ ° ′ ″	Log pΔ		App. Pl. Red. of ★	
Nov. 17	7 35 3	4 4	+0 16.52	+1 17.6	23 37 24.72	−3 16 44.3	8.522n	0.820	+4.09	+26.8
Nov. 19	7 18 1	5 7	+0 2.08	−0 24.8	23 52 46.84	−0 57 39.3	8.891n	0.804	+4.12	+27.0

Mean Place of Comparison Stars

h m s	° ′ ″	
23 37 4.11	−3 18 28.7	*A. G. Straszburg* 8117
23 52 40.64	−0 57 41.5	*A. G. Nicolajew* 5922

Measures made with clock running in both right ascension and declination.

Minneapolis, Minn., January 20, 1920.

ETOILES DOUBLES NOUVELLES,

Par ROBERT JONCKHEERE.

Les quelques nouvelles étoiles doubles suivantes ont été découvertes pendant l'été 1914. Elles font suite à celles publiées dans *A. J.*, 753. Nous avons retrouvé ces observations sur nos anciens livres d'avant-guerre. Nous regrettons de les publier sans mesures supplémentaires, mais les troupes allemandes ayant détruit nos instruments avant leur départ de l'Observatoire, nous ne pourrions obtenir d'autres mesures avant un temps assez long.

J 1331 Anon.
$16^h\,41^m\,44^s$ +1° 12′

	°	″	
1914.486	281.4	3.38	9.4–12.2

J 1332 Anon.
$17^h\,51^m\,57^s$ +3° 21′

1914.609	44.0	1.59	11.0–12.0
.612	46.2	1.37	10.5–12.5
.611	45.1	1.48	10.8–12.3

J 1333 Anon.
$17^h\,53^m\,52^s$ +3° 29′

1914.609	348.0	2.15	9.6–11.5
.612	344.2	1.89	9.8–11.0
.611	346.1	2.02	9.7–11.3

J 1334 Anon.
$19^h\,15^m\,57^s$ +8° 54′

1914.612	180.0	2.73	9.5–12.0

J 1335 *B. D.* +19° 1145
$19^h\,42^m\,57^s$ +19° 12′

1914.528	360.6	0.80	9.4–9.5
.751	355.5	0.98	9.4–9.5
.639	358.0	0.89	9.4–9.5

J 1336 Anon.
$19^h\,46^m\,7^s$ +6° 25′

	°	″	
1914.617	4.6	2.65	9.7–9.8

J 1337 Anon.
$20^h\,2^m\,26^s$ +6° 28′

1914.617	115.4	2.19	10.0–11.0

J 1338 Anon.
$20^h\,4^m\,57^s$ +12° 9′

1914.727	42.2	2.62	9.7–9.7

J 1339 Anon.
$20^h\,7^m\,14^s$ +5° 58′

1914.724	15.0	2.10	9.6–10.5

J 1340 Anon.
$20^h\,14^m\,8^s$ +17° 40′

1914.631	312.6	1.86	9.4–9.4

J 1341 Anon.
$20^h\,17^m\,9^s$ −4° 23′

1914.694	260.6	2.02	9.4–11.0
.699	253.5	2.10	9.4–12.0
.696	257.1	2.06	9.4–11.5

J 1342 Anon.
20h 20m 43s +2° 17′

	°	″	
1914.709	291.0	2.93	9.4–11.5

J 1343 Anon.
20h 23m 10s +9° 52′

1914.628	41.6	2.10	9.6– 9.9
.631	49.8	1.97	9.6–10.0
.630	45.7	2.04	9.6–10.0

J 1344 Anon.
20h 30m 58s +11° 4′

1914.628	116.0	2.18	9.1–11.5

J 1345 Anon.
20h 40m 1s +14° 22′

	°	″	
1914.727	278.6	2.97	9.6–10.5

J 1346 Anon.
20h 52m 4s +8° 19′

1914.729	330.6	2.10	10.0–10.0

(3415) J 157 est à −0m 8s, −0° 3′

J 1347 *B. D.* +13° 5013
22h 49m 0s +13° 41′

1914.732	345.4	1.17	9.3– 9.3

Observatoire de l'Université de Lille.
Hem, le 25 novembre, 1919.

EPHEMERIS OF ASTEROID (659) *NESTOR*.

By FRANK E. SEAGRAVE.

1920 Greenwich Midnight	α	δ	Log r	Log Δ
	h m s	° ′ ″		
Mar. 19	12 58 29	−8 37 33	0.73988	0.65677
23	12 56 39	−8 28 26	0.73972	0.65485
27	12 54 45	−8 18 46	0.73950	0.65331
31	12 52 48	−8 8 35	0.73930	0.65225
Apr. 4	12 50 50	−7 58 10	0.73912	0.65169 = ☍
8	12 48 52	−7 47 37	0.73890	0.65156
12	12 46 56	−7 36 54	0.73872	0.65196
16	12 45 4	−7 26 19	0.73852	0.65279
20	12 43 14	−7 15 54	0.73830	0.65407
24	12 41 30	−7 5 53	0.73810	0.65582

☍ April 3, 1920.

A FAINT STAR WITH LARGE PARALLAX, *B. D.* +61°2068.

By ZACCHEUS DANIEL and FRANK SCHLESINGER.

According to the *Cincinnati Catalogue of Proper-Motion Stars*, the position of this object for 1900 is 20h 51m 16s, +61° 47′ 44″. The same authority gives the proper-motion as 0″.77 in position angle 180°. The visual magnitude and the spectrum in the new *Draper Catalogue* are respectively 8.6, *K*2; these have been kindly communicated by PROFESSOR BAILEY in advance of publication. In a recent letter from DR. ADAMS of the Mount Wilson Observatory the star is stated to be a "dwarf M."

Fifteen plates of this object were secured here between October 1915 and October 1918. These were measured by MR. DANIEL and they yield for the relative parallax:

+0″.134 ±″.007

The absolute visual magnitude of this star is therefore 9.3 and the absolute photographic magnitude, 10.5. The motion at right angles to the line of sight is 26 kilometers a second.

A star of about the same magnitude precedes this at a distance of 84″. It does not share the large proper-motion. Additional proof that there is no physical connection between the two objects is furnished by the small parallax that we derive from our plates for the preceding star, referred to the same comparison stars: −0″.015 ±0″.008.

Allegheny Observatory of the University of Pittsburgh,
January 7, 1920.

OBSERVATIONS OF COMETS,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Comet BRORSEN II Periodic

1919	W. M. T.	☄'s apparent place α	☄'s apparent place δ	☄ − ★ Δα	☄ − ★ Δδ	Comp.	log pα	log pδ	Ap. pl. red of ★ α	Ap. pl. red of ★ δ	Seeing	Obs.	★
	h m s	h m s	° ′ ″	m s	′ ″				s	″			
Aug. 22	11 48 19	22 46 16.98	+28 50 46.4	−0 2.16	−0 35.7	d12, 10	9.103n	0.206	+4.31	+23.5	p	B	1
23	12 6 19	22 43 39.03	+31 4 2.9	−3 6.94	−1 11.9	t25, 5	8.865n	0.081	+4.34	+23.4	p	Bn	2
28	14 0 58	22 21 27.64	+45 30 15.5	−3 20.49	−0 28.4	t35, 7	9.530	9.510n	+4.53	+23.9	f	Bn	3
Sept. 2	10 50 56	21 17 47.85	+64 41 51.5	−0 21.47	+4 27.4	d12, 10	8.926	0.583n	+4.49	+26.5	p	B	4
13	8 45 5	12 46 56.21	+58 21 22.8	+0 18.32	+0 39.9	d12, 10	9.909	0.701	−0.04	− 8.4	p	B	5

Aug. 22. Easily visible in 5-in. finder. Stellar nucleus 12^m. Diffused nebulosity extends over 10′. Aug. 23. Faintly visible in 5-in. finder. Nucleus faint; could not see it well enough for satisfactory comparisons on account of haze. Aug. 28. Visible in 2-in. finder. Faint nucleus. Sep. 2. Poor observation. Sep. 13. Visible in 2-in. finder, probably to naked eye. Very diffuse. Head about 20″ in diameter.

Comet 1919 *c* (METCALF)

1919	W. M. T.	☄'s apparent place α	☄'s apparent place δ	☄ − ★ Δα	☄ − ★ Δδ	Comp.	log pα	log pδ	Ap. pl. red of ★ α	Ap. pl. red of ★ δ	Seeing	Obs.	★
Aug. 25	10 3 10	14 7 54.01	+25 59 10.9	+2 13.55	+9 41.8	t35, 7	9.706	0.704	+1.86	− 0.5	vp	B	7
26	8 42 19	14 9 22.39	+25 36 27.8	+0 9.04	−2 54.0	d 9, 8	9.681	0.609	+1.86	− 0.3	vp	Bn	8
28	9 16 15	14 12 36.28	+24 47 15.1	−0 16.04	−5 5.9	t30, 10	9.698	0.663	+1.85	− 0.2	p	Bn	9
Sept. 2	8 38 0	14 20 53.28	+22 43 26.5	+0 24.37	−3 3.4	d12, 10	9.681	0.644	+1.85	− 0.3	vp	B	10
12	8 8 14	14 38 59.60	+18 22 15.2	−0 19.33	−1 39.3	d12, 10	9.664	0.662	+1.89	− 0.6	vp	B	11
24	7 17 7	15 3 24.26	+12 47 18.3	+0 8.45	−0 44.4	d10, 8	9.653	0.693	+1.95	− 0.3	p	B	12
Oct. 3	7 35 0	15 23 41.93	+ 8 20 0.0	−0 20.25	+1 7.1	d10, 8	9.648	0.714	+2.04	+ 0.1	p	B	14

Aug. 25. $14\frac{1}{2}^m$. Poor observation, hurried. Very hazy. Aug. 26. Visible in 2-in. finder. Faint nucleus. Poor observation. Aug. 28. Visible in 2-in. finder. Sep. 2. Faint at times. Moonlight. Passing clouds. Poor observation. Oct. 3. Poor observation.

Observers: Bn = H. E. BURTON; B = ERNEST CLARE BOWER. Comp.: *d* = direct measures, clock running; *t* = transits.

Mean Places of Comparison Stars for 1919.0

★	α	δ	Authority	★	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	22 46 14.83	+28 50 58.6	*A.G. Camb.Eng.* 13735	8	14 9 11.49	+25 39 22.1	*A.G. Camb. Eng.* 6752
2	22 46 41.63	+31 4 51.4	*A.G. Leiden* 9696	9	14 13 20.47	+24 52 21.2	½ { *A G. Camb. Eng.* 6780; *A G. Berlin B* 5032 }
3	22 24 13.60	+15 30 20.0	*A.G. Bonn* 16754	10	14 20 27.06	+22 46 30.2	½ { *Ast. Par.* +22.1416, 73; *Ast Par* +22.1424, 4 }
4	21 18 4.83	+64 36 57.6	½ { *Ast. Rom* +64 2118, 23302; *Ast Gen* +65.2109, 7304 }	11	14 39 17.04	+18 24 25.1	*Cinc. Pub. No. 18*; 4 1940
5	12 46 37.93	+58 20 51.3	{ $12\frac{1}{2}^m$, comp. with 6, 1919 Sep. 18, $\Delta\alpha = -1^m 10^s.11$, $\Delta\delta = +10'32''.6$, 1919.0 }	12	15 3 13.86	+12 48 3.0	{ 12^m, comp. with 13, 1919 Oct. 2, $\Delta\alpha = -1^m 39^s.92$, $\Delta\delta = +0'10''.4$, 1919.0 }
6	12 47 48.04	+58 10 18.7	*A.G. Hels.* 7337	13	15 4 53.78	+12 47 52.6	*A.G. Leipzig I* 5315
7	11 5 38.60	+25 49 29.6	*A.G. Camb. Eng.* 6732	14	15 24 0.14	+ 8 15 52.8	*Ast. Toul.* +9.1524, 124

U. S. Naval Observatory, Washington, D. C.,
1919, December 15.

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EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS: E. E. BARNARD, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD.
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THE

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NOTE ON AN ANNUAL TERM IN THE RIGHT ASCENSIONS,

[Second Paper.]

By M. L. ZIMMER.

It was stated in the first paper[1] that we hoped and expected to have, by the end of 1918, sufficient data to effect a complete solution of the problem; but on account of almost unprecedented bad weather conditions, during the latter part of last year and extending almost up to the present, the proposed program has been only partially carried out, so that, even now, we are not in possession of the observations on the results of which we were to have attempted an explanation. As the program cannot be carried out now before the middle of next year, at the earliest, it seems desirable to publish a note at this time, setting forth what has been accomplished to date, rather than to await the accumulation of data, which when had may not be adequate to effect a satisfactory explanation of the phenomenon.

At the June and December solstices the 0 and 12 hour groups were observed and reduced in the same manner as were the 6 and 18 hour groups at the equinoxes and the following table, setting forth the results, shows that what was said in the first paper about the 6 and 18 hour groups applies equally to these two groups. At the June solstice most of the observations were made (both morning and evening) during darkness and those at the December solstice, for the most part, during daylight so that practically all day − night effect has been eliminated.

Table I

Star	1900.0 α	1900.0 δ	Mag.	Spectr.	μ	Obs. Δ	$Z-B$
	h m	° ′			″	s	s
α *Andromeda*	0 3.2	+28 32	2.0	*A0p*	.213	+.050	+.009
γ *Pegasi*	8.1	+14 38	2.9	*B2*	.013	+.038	+.035
ι *Ceti*	14.3	− 9 23	3.7	*K0*	.036	+.019	+.034
Br 38	24.9	− 4 31	6.3	*K5*	.010	+.019	+.048
β *Ceti*	38.6	−18 32	2.0	*K0*	.231	+.020	+.019
ϵ *Corvi*	12 5.0	−22 4	3.1	*K0*	.066	+.044	−.031
γ *Corvi*	10.7	−16 59	2.6	*B8*	.162	+.041	−.020
η *Virginis*	14.8	− 0 7	4.0	*A0*	.066	+.014	−.005
δ *Corvi*	24.7	−15 58	3.0	*A0*	.252	+.034	−.031
β *Corvi*	29.1	−22 51	2.8	*G5*	.061	+.015	−.018

Δ = Difference between June and December results in the sense Morning − Evening.
$Z-B$ is the indicted correction to the *P. G. C.*

At the last three successive solstices the 6 and 18 hour groups have been observed. Since at the solstices these two groups transit at mid-day and mid-night it was found difficult to eliminate the day − night effect, so to these observations its effect, evaluated from the March and September results, of which there was an ample amount of material, was applied. From this investigation it was found that stars transit relatively

[1] *Astron. Jour.* 32, 1, 1919.

earlier by ^{s}.015 in daylight than in darkness with the probability that it is slightly greater near noon than it is just at the point of change from daylight field to illuminated or vice versa. This value agrees in sign and approximately in size with that found at Washington. From these observations we find that there is no systematic difference between clock corrections obtained at mid-day and those at mid-night when the systematic errors of star places have been eliminated, and furthermore, since the resulting right ascensions of these mid-day and mid-night observations are identical with those of the mean of the March and September results which were found from observations made at or near six o'clock in the evening and morning respectively, it would seem that we are justified in concluding that these are the true right ascensions and that the indicated systematic corrections of $-^s.020$ for the 6 hour group and $+^s.020$ for the 18 hour group are real and actually represent the systematic errors of Boss' *P. G. C.* for these two groups. Since the resulting right ascensions from these mid-day and mid-night observations are identical with those of the mean of the March and September results, it shows that the systematic difference between evening and morning observations is eliminated when we take the mean of the two; but that it is not eliminated from either evening or morning observations, although they are reduced with clock corrections made up of the mean of two determinations from groups of stars separated by twelve hours.

After the day – night effect had been evaluated, new reductions of the two complete programs of the 6 and 18 hour groups, observed at the equinoxes of 1917 and 1918, were made so as to eliminate it from these results. The following table gives the new Δ's freed from the day – night effect and it will be noticed that they no longer exhibit dependence on right ascension. The mean Δ not changing perceptibly shows how completely the effect was eliminated in the first reduction. The close agreement of the individual Δ's of the independent determination of 1918 with that of the previous year points to a very real and definite cause which appears to act with the fidelity of gravity itself. The agreement would probably have been still better had not the bad weather prevented the carrying out of the program in September 1918. As it is the results at that equinox have only half weight. A casual glance is enough to convince one that the Δ's are not the same for all stars, and this becomes more evident if we examine them from the stand-point of their probable errors. The probable error of one determination of any Δ is $\pm^s.006$ if computed from the differences between the two independent determinations and the probable error for the mean of the two would then be $\pm^s.004$. If we compute the probable error directly from the observations, taking $\pm^s.014$ as the probable error of a single determination of right ascension (certainly not greater and probably less) we find almost exactly the same value $\pm^s.004$ for any mean Δ. But if we assume that the Δ's are the same for all stars and compute the probable error from the differences which result from subtracting each Δ from the mean of all we find it to be more than double that computed from the differences of the two independent determinations and if we compute the probable error of a Δ for either year separately we find it to be just about the same as for the mean of both, thus showing that by doubling the number of determinations we do not diminish the probable error.

We can only conclude from this that the Δ's are not the same for all stars, thus confirming what was tentatively stated in the first paper. In order to save space only the 6 hour group is given; but what has been said here applies equally to the 18 hour group.

Table II

Star	1900.0	δ	Mag.	Spectr.	μ	1917 Obs. Δ_1	1918 Obs. Δ_2	Mean
	h m	° ′			″	s	s	s
γ *Orionis*	5 19.8	+ 6 16	1.6	*B2*	.020	+.050	+.028	+.039
β *Leporis*	24.0	−20 50	2.7	*G*	.094	.050	.041	.046
δ *Orionis*	26.9	− 0 22	2.2	*B*	.003	.054	.060	.057
α *Leporis*	28.3	−17 54	2.6	*F*	.004	.041	.042	.042
ι *Orionis*	30.5	− 5 59	2.9	*Oe5*	.005	.046	.054	.050
β *Doradus*	32.8	−62 33	3.8	*F*	.016	.077	.079	.078
σ *Orionis*	33.7	− 2 39	3.8	*B*	.001	.047	.030	.038
ζ *Orionis*	35.7	− 2 0	1.7	*B*	.007	.044	.031	.037
γ *Leporis*	40.3	−22 29	3.7	*F*	.468	.059	.053	.056
ζ *Leporis*	42.4	−14 52	3.6	*A*	.018	.041	.042	.042
δ *Doradus*	44.6	−65 46	4.5	*A*	.039	.048	.077	.062

Star	1900.0 α	δ	Mag.	Spectr.	μ	1917 Obs. Δ_1	1918 Obs. Δ_2	Mean
	h m	° ′			″	s	s	s
β *Columbæ*	47.4	−35 48	3.0	*K*	.397	.038	.042	.040
α *Orionis*	49.8	+ 7 23	1.0 V.	*M*	.029	.052	.041	.046
η *Leporis*	51.9	−14 11	3.7	*F*	.138	.048	.046	.047
γ *Columbæ*	54.0	−35 18	4.4	*B3*	.004	.046	.033	.040
η *Columbæ*	56.1	−42 49	3.9	*K*	.033	.033	.023	.028
Br. 880	58.0	+23 16	4.3	*G*	.108	.050	.062	.056
ν *Orionis*	6 1.9	+14 47	4.4	*B*	.037	.039	.028	.034
δ *Pictoris*	8.4	−54 57	4.9	*B*	.022	.031	.022	.027
Br. 920	10.0	− 6 15	4.2	*K*	.021	.030	.032	.031
κ *Columbæ*	13.0	−35 6	4.5	*K*	.076	.019	.025	.022
ζ *Can. Maj.*	16.5	−30 1	3.0	*B3*	.008	.036	.038	.037
β *Can. Maj.*	18.3	−17 54	1.8	*B1*	.007	.022	.048	.035
α *Carinæ*	21.7	−52 38	0.	*F*	.018	.054	.050	.052
ν *Geminorum*	23.0	+20 17	4.1	*B*	.023	.042	.041	.042
λ *Can. Maj.*	24.5	−32 31	4.5	*B5*	.032	.040	.015	.028
ξ *Can. Maj.*	27.7	−23 21	4.4	*B1*	.008	.035	.036	.035
Br. 972	30.9	−22 53	4.6	*A*	.014	.037	.015	.026
γ *Geminorum*	31.9	+16 29	1.8	*A*	.065	.062	.057	.060
ν *Puppis*	34.7	−43 6	3.1	*B8*	.020	.037	.057	.047
S Monocerotis	35.5	+ 9 59	5± V.	*Oe5*	.008	.053	*	
ε *Geminorum*	37.8	+25 14	3.1	*G*	.020	.038	.043	.040
ξ *Geminorum*	39.7	+13 0	3.3	*F*	.231	.045	.047	.046
Sirius	40.7	−16 35	−2.0	*A*	1.316	.075	.103	.089

* Not observed.

Prof. Tucker[1] suggests that the cause of this unique phenomenon may be found in some form of lateral refraction. That hypothesis was almost the very first to be considered here; but was rejected on the ground that no form of refraction would make stars in the same region of sky give such widely varying Δ's. Prof. Bigelow, the eminent meteorologist of the Argentine Weather Bureau, has been interested in this investigation from the first and has gone over it with me somewhat in detail. He has just finished an exhaustive study of the upper atmosphere and has developed a series of curves which represent its diurnal changes. One of these, the so called density curve, represents a condition that may in some way give rise to the observed phenomenon; but neither he nor I can understand how refraction could give one value to one star and quite a different value to another in proximity to it.

Wagner[2] in discussing the Poulkova observations for 1845 says: "Il y a une différence constante prononcée entre les Δ A. R. α Canis Min. − α *Aquilæ*, déduites des observations pendant lesquelles α *Canis Min.* passe par le méridien apres midi ou avant midi." I have taken some pains to investigate this from the material which is given in convenient form in the Poulkova volumes and find that it unquestionably refers to the same phenomenon, since the difference he refers to is of the same sign and of approximately the same magnitude.

Kapteyn[3] discussing the Leiden observations has noted what is probably the same thing. These, together with Tucker's results, show that the phenomenon is not a local one but that it is very nearly, if not exactly, the same for all localities and for all observers. This, then, confirms our conclusion that the systematic errors in the right ascensions of practically all star catalogs have had their origin in this phenomenon.

In the future, if we are to free our fundamental systems from these large systematic errors and keep

[1] *Lick Observatory Bulletin*, No. 323.

[2] *Observations de Poulkova*, Volume III, p. 3.

[3] *Leiden Annual*, Volume VII, p. 141.

them free either we must find the true explanation of this phenomenon and reduce it to formula so that it can be inserted in the apparent place reduction or make the observations in such a way as to eliminate its effect. This may be done by observing groups of stars separated by intervals of twelve hours and repeating the program six months later when the groups will be reversed with respect to evening and morning. To completely eliminate the effect all stars should have the same number of observations in the morning as in the evening — a condition not at all easy to satisfy especially where large programs are to be observed.

We now have some 10,000 observations, designed especially for the solution of this problem, distributed through the twelve months. They are not evenly distributed; but there is no month that is not represented. Most of the observations have been made at or near the equinoxes and solstices and are, therefore, inadequate to determine definitively what form of curve the phenomenon describes during the year. They do, however, fix those four points with a considerable degree of accuracy and in conjunction with what testimony is furnished by the few observations scattered along at intermediate points show that the curve is probably a continuous one and that it is almost certainly of the well known sine form. This point is being investigated now and will be treated in a subsequent paper.

No explanation is advanced at this time; but as stated in the first paper parallax is the only thing known to astronomy, so far as I am aware, that is adequate to explain the observed facts and parallax does explain them. It is, however, impossible according to present accepted notions, to understand how parallax of such size can exist; but to simply deny that it is parallax on the ground that it is too large neither serves to prove that it is not nor helps to explain what it really is. It seems to me that the satisfactory solution of this problem is essential to the progress of positional astronomy and in order to hasten its solution the problem deserves the cooperation of all observers equipped with good modern apparatus capable of detecting quantities of such small magnitude.

Observatorio Nacional Argentino,
Córdoba, October, 1919.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN PENNA., WITH A $4\frac{1}{2}$-INCH TELESCOPE,

By A. W. QUIMBY.

1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
July 1	7	–	4	11	1	fair
2	7	5	5	35	4	fair
3	7	1	7	37	4	fair
4	7	1	7	18	3	fair
5	4	–	4	14	2	fair
6	7		4	16	2	fair
7	7	–	3	9	2	fair
8	7	–	4	9	3	fair
9	7	1	4	15	3	fair
10	7	0	4	10	3	fair
11	7	1	3	15	3	fair
12	7	2	5	45	3	fair
13	7	0	4	47	2	poor
14	7	2	6	35	4	fair
15	7	1	6	17	2	poor
16	7	0	6	15	2	poor
17	7	–	5	9	1	poor
19	1	1	5	9	1	poor
20	12	1	5	7	2	poor
21	6	–	5	5		poor
July 22	12	–	5	5	–	poor
23	6	2	7	20	1	fair
24	6	–	7	24	3	fair
25	7	2	9	31	2	v. g.
26	7		7	16	4	fair
27	7	–	6	11	3	fair
28	6	1	5	6	4	fair
29	7	–	3	5	3	fair
30	7		3	5	4	fair
31	7	–	3	5	2	fair
Aug. 1	7	–	3	5	3	fair
2	7	1	2	5	4	fair
3	7	–	1	1	3	fair
4	7	2	3	10	4	fair
5	6	2	4	11	4	fair
6	6	1	4	10	2	poor
7	6	1	4	20	3	good
8	6	1	5	31	3	good
9	6		4	40	4	good
10	7	–	4	20	2	fair
Aug. 11	1	2	5	41	2	good
12	7	–	5	26	2	fair
14	6	4	9	44	2	good
15	8	–	9	46	2	good
16	7	–	8	42	2	fair
17	5	–	6	40	–	poor
18	12	1	6	103	2	v. g.
19	8	–	5	100	1	fair
20	6	–	4	92	–	good
21	6	2	5	100	2	good
22	6	2	7	68	4	good
23	6	1	6	65	4	good
24	6	–	5	17	3	good
25	7	–	3	11	1	good
26	6	2	5	27	3	good
27	6	–	2	14	1	fair
28	6	–	3	11	2	fair
29	6	1	3	8	3	fair
30	2	–	2	5	–	poor
31	7	–	3	8	–	fair

1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Sept. 1	6	–	2	11	1	fair
2	7	–	2	11	–	fair
3	6	2	4	24	4	fair
4	7	–	4	21	4	fair
5	5	–	3	29	3	fair
6	6	1	3	17	2	fair
7	7	–	3	11	2	fair
8	7	2	4	8	2	fair
9	8	–	2	6	–	poor
11	6	1	3	22	–	fair
12	6	–	3	20	–	fair
13	7	–	3	17	2	fair
14	7	1	4	20	2	fair
15	7	–	4	20	2	fair
16	7	0	2	16	1	fair
17	7	–	2	8	1	fair
18	7	1	3	10	2	fair
19	7	–	2	8	2	fair
20	6	2	4	25	2	fair
21	5	–	3	38	3	fair
22	7	–	3	20	2	fair
24	7	2	4	30	2	fair
25	4	–	5	53	2	fair
26	10	–	3	28	2	fair
27	6	2	6	25	2	fair
28	7	1	6	22	3	fair
29	7	2	7	35	2	fair
30	9	–	5	17	1	fair
Oct. 3	9	3	11	1	–	fair
5	12	1	3	13	2	good
6	4	–	3	7	2	fair
7	9	2	5	6	2	poor
8	7	–	5	7	2	fair
9	7	2	6	9	2	poor
10	3	–	6	33	1	fair
11	3	–	6	54	1	good

1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Oct. 13	7	–	5	60	1	fair
16	11	–	4	28	1	fair
17	10	–	4	13	1	fair
18	8	–	3	9	1	fair
19	8	–	2	6	2	fair
20	8	1	2	3	1	poor
21	8	–	1	2	2	fair
22	8	–	1	2	2	fair
24	2	1	2	3	1	poor
26	12	–	1	1	–	poor
27	12	1	3	7	1	fair
28	8	1	4	8	1	fair
29	8	1	5	38	2	fair
20	10	–	2	16	–	poor
31	4	–	5	75	2	fair
Nov. 1	8	1	4	103	1	fair
2	8	1	5	66	1	fair
3	8	–	5	50	1	poor
4	9	–	5	55	2	poor
5	9	–	4	25	2	poor
6	8	–	4	15	2	fair
7	9	1	4	7	2	fair
8	8	1	4	6	2	fair
9	8	–	4	8	2	fair
10	8	–	3	6	1	fair
12	8	–	3	3	2	poor
13	3	–	2	3	1	poor
14	8	–	1	2	1	fair
15	8	1	2	3	1	fair
16	8	–	1	5	3	fair
17	8	–	1	5	2	fair
18	8	–	1	3	3	fair
19	8	1	1	3	1	fair
20	8	–	1	3	1	fair
21	8	–	1	5	1	fair
22	8	1	1	2	1	fair

1919	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Nov. 23	8	2	3	7	2	fair
24	8	–	3	13	1	fair
25	8	–	2	5	2	poor
26	2	–	1	4	–	poor
27	9	1	2	13	1	fair
28	8	–	2	32	2	fair
29	8	–	2	6	–	poor
30	8	2	4	8	3	poor
Dec. 1	10	1	5	15	3	poor
2	12	–	5	15	2	poor
3	8	1	6	20	2	poor
4	8	–	5	19	2	fair
5	8	–	4	8	2	poor
6	9	–	1	1	–	poor
7	12	–	2	4	2	fair
10	3	2	3	9	2	fair
11	8	–	2	10	2	fair
14	2	–	2	21	1	poor
15	8	1	2	21	1	poor
16	8	–	2	15	1	poor
17	8	–	2	16	3	poor
18	3	–	1	3	–	v. p.
20	10	–	1	1	2	fair
21	8	1	1	5	2	fair
22	9	1	2	10	3	fair
23	8	1	3	10	3	fair
24	8	–	1	1		v. p.
25	9	–	1	6	1	fair
26	8	–	1	6	–	fair
27	3	–	1	5		fair
28	9	–	1	3	–	poor
29	8		1	3	–	poor
30	9	–	2	13	1	poor
31	8	–	2	20	3	poor

NOTE ON THE PARALLAXES AND PROPER-MOTIONS OF THE TWO FAINT STARS *B. D.* +8°3689 AND *B. D.* +8°3692,

By FRANK SCHLESINGER.

The positions of these two objects for 1900 are:

B. D. +8° 3689	$18^h\,21^m\,25^s$	+8° 43′ 58″
B. D. +8° 3692	18 21 36	8 34 14

The visual magnitudes are 8.0 and 8.5 and the spectra *G1* and *G5* respectively.

The relative parallaxes and proper-motions in right ascensions have been determined here from plates taken with the Thaw Refractor, for the first star by Miss Knudsen and the writer, and for the second by Dr. Henroteau:

	Relative parallax	Relative proper-motion in right ascension
B. D. +8° 3689	+″.026 ±″.009	−″.196 ±″.010
B. D. +8° 3692	+ .037 ± .012	− .214 ± .010

To get the absolute parallaxes we should add ″.005. Adams and Joy have determined the parallaxes by the spectroscopic method: +″.052 and +″.018. Giving equal weight to these values and our own we have for the means +″.041 and +″.030 (absolute). Kapteyn and Weersma give +″.037 for the mean absolute parallax of the two stars, as determined from plates taken by Donner and measured at Groningen. If we assume that the two parallaxes are really the same the mean from all the data is +″.036 ±″.005 (absolute).

The proper-motions of these two stars are given in the *Cincinnati Catalogue of Proper-Motion Stars* (derived from meridian observations), and also in No. 19 of the *Groningen Publications* (from measurements of photographs):

	Proper-motion in declination	Proper-motion in right ascension
B. D. +8° 3689	−″.50	−″.237 (Cincinnati)
	− .456	− .167 (Groningen)
		− .196 (Allegheny)
B. D. +8° 3692	−″.47	− .178 (Cincinnati)
	− .458	− .194 (Groningen)
		− .214 (Allegheny)

In all probability the two stars have essentially the same proper-motion, the means being −″.47 and −″.20, equivalent to a total proper-motion of ″.51 in position angle 203°.

It is evident that these two stars form one of those interesting systems (like *Capella*, *α Centauri* and others that have recently come to light) in which two stars are separated by linear distances that make their mutual attraction negligibly small, and yet their physical connection (in some sense) is shown by the presence of large proper-motion common to the two stars. In this case, assuming that the parallax is +″.036, the distance between the two stars is at least 17,000 times that between the *Earth* and the *Sun*, and may be much greater than this if the line joining the stars makes a small angle with our line of sight. Assuming that the combined mass of the two is equal to that of the *Sun*, their attraction for each other is so feeble that more than two million years would be required for them to complete one revolution around each other.

Allegheny Observatory, University of Pittsburgh, January 27, 1920.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL OF GOODSELL OBSERVATORY,

By H. C. WILSON.

Date	Gr M. T.	Δα	Δδ	No. of Comps.	App. α	App. δ	log pΔ α	log pΔ δ	★
				Comet *b* 1919 (Brorsen-Metcalf)					
	h m s	m s	′ ″		h m s	° ′ ″			
Aug. 30	16 05 26	+0 05.60	+ 1 14.7	16 , 8					1
		+2 07.72	− 0 44.3	4 , 2	22 05 56.85	+52 24 15.8	9.463*n*	9.890*n*	2
Sept. 15	15 15 23	+1 55.25	− 6 34.6	9 , 6	12 28 15.07	+52 21 59.9	9.762	0.808	3
17	15 05 32	+0 01.12	− 9 02.7	6 , 6					4
		−1 57.84	− 2 09.3	6 , 2					5
		+0 18.57	− 7 40.1	10 , 2	12 16 20.84	+47 18 50.9	9.704	0.834	6
19	13 43 05	+0 10.89	− 3 44.3	6 , 6					7
		+0 04.43	− 4 38.3	3 , 2					8
		−0 00.49	−11 34.1	2 , 2	12 08 06.63	+43 02 07.7	9.736	0.767	9
22	14 00 20	+0 35.71	+ 2 55.1	9 , 6					10
		−0 08.28	+ 7 07.9	9 , 3	11 59 11.74	+37 25 06.3	9.669	0.824	11
				Comet *c* 1919 (Metcalf-Borrelly)					
Aug. 30	11 54 59	−0 05.68	+ 4 51.4	12 , 6	14 15 54.79	+23 57 25.0	9.646	0.694	12
Sept. 15	14 13 21	−0 41.92	+ 0 11.8	18 , 6	14 44 54.29	+17 00 00.2	9.623	0.726	13
19	15 05 51	−0 04.21	+ 4 22.0	6 , 6	14 53 02.80	+15 07 41.6	9.638	0.768	14
22	14 59 31	+0 25.46	− 4 34.7	9 , 6	14 59 18.51	+13 42 28.8	9.635	0.771	15
26	13 37 23	−0 09.68	+ 1 20.4	6 , 6	15 07 50.12	+11 48 02.6	9.602	0.744	16

Date	Gr. M.T.	Δα	Δδ	No. of Comps.	App. α	App. δ	log pΔ α	log pΔ δ	★
					Comet c 1919 (Metcalf-Borrelly)				
1919	h m s	m s	′ ″		h m s	° ′ ″			
Oct. 2	13 38 24	+1 01.32	+ 3 07.4	9 , 6	15 21 27.02	+ 8 49 12.9	9.606	0.760	17
10	13 39 32	−0 30.90	− 5 06.6	12 , 6	15 40 59.77	+ 4 42 04.0	9.609	0.777	18
18	13 01 25	−0 35.95	+ 3 47.4	11 , 6	16 01 36.77	+ 0 27 27.0	9.591	0.786	19
21	12 59 08	+0 44.04	+ 1 09.9	9 , 6	16 09 50.11	− 1 10 26.9	9.592	0.791	20
28	13 22 32	+0 16.99	− 7 23.5	9 , 6	16 29 56.69	− 5 00 29.9	9.612	0.795	21
					Comet a 1919 (Kopff's Periodic)				
Sept. 19	15 59 06	+0 15.20	+ 4 51.8	10 , 6					22
		+2 05.63	− 1 16.6	6 , 2	19 53 15.60	− 7 57 17.6	9.273	0.836	23
23	15 55 58	−0 40.01	+ 0 18.5	12 , 6	19 58 05.74	− 7 54 41.1	9.302	0.835	24
Oct. 16	14 37 13	+0 10.08	+ 2 51.2	6 , 6					25
		+0 01.49	+ 7 35.7	5 , 4	20 30 42.87	− 7 19 52.8	9.219	0.834	26
					Comet d 1919 (Finlay-Sasaki)				
Nov. 14	14 25 21	−0 11.43	− 1 53.4	6 , 6	23 13 08.25	− 6 52 51.5	8.768	0.835	27
15	11 32 37	−0 07.17	+ 0 05.8	6 , 6					28
		−0 55.18	+ 1 22.3	6 , 3	23 21 29.49	− 5 38 47.7	8.807	0.827	29
17	13 19 47	+0 07.39	+ 0 10.2	8 , 6	23 37 15.58	− 3 17 51.7	8.922n	0.811	30
18	15 56 38	−0 06.21	+ 0 59.0	6 , 6	23 45 54.34	− 1 59 53.5	9.275	0.801	31
19	14 43 24	+0 24.78	+ 2 34.9	6 , 6	23 53 09.66	− 0 54 38.3	8.708	0.794	32
21	14 00 37	+0 05.67	+ 1 37.7	6 , 6					33
		−0 30.74	+ 6 01.5	9 , 3	0 07 38.68	+ 1 15 27.4	8.554n	0.778	34
25	14 23 52	−0 03.39	− 1 28.1	6 , 6	0 34 48.48	+ 5 15 04.8	8.149n	0.743	35

The observations have been corrected for refraction and the reductions have all been thoroughly checked by Prof. C. H. Gingrich.

Comparison Stars

Mean places for 1919.0 and Reductions to Apparent place.

★	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	22 05 46.67	+52 22 36.4		...	*B. D.* +52° 3121
2	22 03 38.95	+52 23 20.7	+4.58	+24.7	*A. G. Harvard* 7462
3	12 26 19.30	+52 28 15.2	+0.52	−10.7	*A. G. Harvard* 4090
4	12 16 18.88	+47 28 05.4			*B. D.* +47° 1951
5	12 18 16.72	+47 30 14 7			*B. D.* +47° 1956
6	12 17 58.15	+47 37 54.8	+0.84	−11.8	Küstner 5471
7	12 07 54.66	+43 06 04.9	.	...	10^m Anonymous
8	12 07 50.23	+43 10 13.2	.		$9^m.5$ Anonymous
9	12 07 50.72	+43 22 17.3	+1.08	−12.9	*A. G. Bonn* 8391
10	11 58 34.69	+37 22 25.0	...	....	*B. D.* +37° 2241 ?
11	11 58 42.97	+37 15 17.1	+1.34	−13.8	*A. G. Lund* 5333

★	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
12	14 15 58.76	+23 52 33.8	+1.71	− 0.2	Paris Ph. +24°, 14h 16m No. 100
13	14 45 34.28	+16 59 48.9	+1.93	− 0.5	Bordeaux Ph. +17°, 14h 44m No. 38
14	14 53 05.08	+15 03 20.0	+1.93	− 0.4	Bordeaux Ph. +15°, 14h 52m No. 46
15	14 58 51.11	+13 47 03.9	+1.94	− 0.4	Bordeaux Ph. +14°, 14h 56m No. 67
16	15 07 57.83	+11 46 42.3	+1.97	− 0.1	*A. G. Leipzig* 5328
17	15 20 23.69	+ 8 46 05.5	+2.01	0.0	Toulouse Ph. +9°, 15h 16m No. 180
18	15 41 18.57	+ 4 47 10.0	+2.10	+ 0.6	Toulouse Ph. +5°, 15h 40m No. 198
19	16 02 10.47	+ 0 23 38.6	+2.25	+ 1.0	Algiers Ph. +0°, 16h 00m No. 46
20	16 09 03.84	− 1 11 38.0	+2.24	+ 1.2	Algiers Ph. −2°, 16h 08m No. 70
21	16 29 37.33	− 4 53 08.7	+2.37	+ 2.3	Munich 1 12717, Warshau 3946
22	19 52 56.47	− 8 02 28.5		......	*B. D.* −8° 5174
23	19 50 50.84	− 8 01 11.9	+3.93	+19.1	*A. G. Wien-Ottakring* 6977
24	19 58 41.85	− 7 55 19.0	+3.90	+19.4	*A. G. Wien-Ottakring* 7044
25	20 30 29.12	− 7 23 05.7		....	Anonymous
26	20 30 27.63	− 7 30 41.4	+3.67	+21.8	Munich 1 25081
27	23 13 15.67	− 6 51 24.3	+4.01	+26.2	*B. D.* −7° 5976. Northfield Ph.
28	23 21 32.62	− 5 39 19.9	..	...	*B. D.* −6° 6208
29	23 22 27.80	− 5 40 42.2	+4.04	+26.4	*A. G. Wien-Ottakring* 8318
30	23 37 04.10	− 3 18 28.8	+4.09	+26.9	*A. G. Strassburg* 8117
31	23 45 56.44	− 2 01 19.5	+4.11	+27.0	Algiers Ph. −2°, 23h 44m No. 75
32	23 52 40.73	− 0 57 40.4	+4.15	+27.2	Algiers Ph. −1°, 23h 48m No. 91
33	0 07 28.81	+ 1 13 22.4		....	10m.5 Anonymous
34	0 07 59.55	+ 1 07 20.9	+4.20	+27.3	Algiers Ph. +0°, 0h 08m No. 20
35	0 34 47.50	+ 5 16 07.9	+4.37	+27.4	Toulouse Ph. 5°, 0h 36m No. 19

ELEMENTS OF COMET *b* 1919 (*METCALF*),

By F. E. SEAGRAVE.

The following elements were computed by Watson's method from three observations by Barnard on the following dates:

1919 Aug. 21.69770 G. M. T.	log Δ	= 9.452094
Sept. 4.93380	log Δ′	= 9.298111
Sept. 16.58374	log Δ″	= 9.449059

Elements

E = Sept. 4.93380, 1919, G. M. T.

M = 359° 25′ 23″.03	Log a = 1.236749
ω = 129 29 32 .08	Log e = 9.987618
π = 80 14 54 .27	Log q = 9.685574
☊ = 310 45 22 .19	μ = 49″.5316
i = 19 12 49 .31	

Equatorial Constants

$$x = r[9.986068] \sin(42° 23' 10''.00 + u)$$
$$y = r[9.913629] \sin(302° 1' 18''.02 + u)$$
$$z = r[9.795708] \sin(331° 9' 10''.32 + u)$$

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y., Associate Editors E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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THE PARALLAX OF *KRUEGER* 60,

By S. A. MITCHELL.

The interest in the binary *Krueger* 60 is due mainly to the work of PROFESSOR BARNARD who has been an assiduous observer of it. Its parallax was determined by him from micrometer measures, and a long and careful series of observations have been made of position angle and distance. An account of these measures is given in *Monthly Notices* 68, 629, 1908 and 76, 592, 1916. From BARNARD's observations and some by DOOLITTLE, RUSSELL has investigated the orbit. (*Astronomical Journal* 30, 131, 1916.) The observations to 1916 are satisfied equally well by either of two orbits, orbit *B* with period of 46.0 years, or orbit *C* with period of 54.9 years.

Owing to the great interest attaching to the star on account of the large proper-motion, large parallax and rapid orbital motion, it was put on the parallax program of the McCormick Observatory. Heretofore, the parallax of the brighter component A only has been determined. The following measures give for the first time the parallax of the component *B*, separated from *A* by 2″, and also of the distant companion, *C*. When first observed by KRUEGER the distance *AC* was 12″. In 1890 BURNHAM found that *A* was an unequal double and this forms the binary system *AB*. Due to the large proper-motion of *AB*, the star *C* has been left behind in space and the distance *AC* has now increased to 54″. The parallaxes depend on 22 plates each with two exposures (except plate 5513), and taken in five successive seasons. All the plates of the series were exposed by the writer except 5511-2-3 and 5570 taken by DR. H. L. ALDEN.

REDUCTIONS FOR *Krueger* 60, *B*

Plate	Date	Solution (m)	Weight (p)	Parallax Factor (P)	Time in Days (t)	Residual (v)	$\sqrt{p.v.}$ in Arc
		mm				mm	″
3418	1916 Nov. 21	+0.1088	1.0	−0.916	−393	+0.0020	+0.04
3419	Nov. 21	+ .1084	1.0	− .916	−393	+ .0024	+ .05
3437	Nov. 26	+ .1098	1.0	− .919	−388	+ .0003	+ .01
3438	Nov. 26	+ .1050	1.0	− .919	−388	+ .0051	+ .11
4166	1917 July 4	+ .1064	1.0	+ .743	−168	− .0025	− .05
4167	July 4	+ .1058	1.0	+ .743	−168	− .0019	− .04
4168	July 4	+ .1082	1.0	+ .743	−168	− .0043	− .09
4696	Nov. 4	+ .0679	1.0	− .853	− 45	+ .0003	+ .01
4697	Nov. 4	+ .0686	0.8	− .853	− 45	− .0004	− .01
4701	Nov. 5	+ .0724	1.0	− .859	− 44	− .0044	− .09
4702	Nov. 5	+ .0706	1.0	− .859	− 44	− .0026	− .05
4727	Nov. 7	+ .0664	1.0	− .870	− 42	+ .0012	+ .02
4728	Nov. 7	+ .0726	1.0	− .870	− 42	− .0050	− .10
5511	1918 July 2	+ .0521	1.0	+ .764	+195	+ .0068	+ .14
5512	July 2	+ .0600	0.7	+ .764	+195	− .0011	− .02

Plate	Date	Solution (m)	Weight (p)	Parallax Factor (P)	Time in Days (t)	Residual (v)	$\sqrt{p.v.}$ in Arc
		mm				mm	″
5513	1918 July 2	+0.0549	0.5	+0.764	+195	+0.0040	+ .06
5570	July 20	+ .0527	0.8	+ .565	+213	+ .0014	+ .02
5871	Nov. 3	+ .0194	0.8	− .846	+319	+ .0035	+ .07
5903	Nov. 7	+ .0210	1.0	− .869	+323	+ .0011	+ .02
5970	Nov. 14	+ .0238	0.8	− .899	+330	− .0029	− .05
5971	Nov. 14	+0.0220	1.0	−0.899	+330	−0.0011	−0.02

The normal equations are:

$$19.4c - 5.474\,\mu - 7.4656\pi = +1.3984\text{mm}$$
$$+120.7411\mu + 6.6985\pi = -1.8222\text{mm}$$
$$+13.6446\pi = -0.4584\text{mm}$$

from which

$$c = +0.07346\text{mm}$$
$$\mu = -0.01247\text{mm per 100 days, or } -0''.946 \text{ per year}$$
$$\pi = +0.01272\text{mm} = +0''.265 \pm 0''.014$$

REDUCTIONS FOR PRINCIPAL STAR A AND COMPANION C

Plate	Date	Weight (p)	Parallax Factor	Time in Days	Star A Solution	Star A $\sqrt{p.v.}$ in Arc	Star B Solution	Star B $\sqrt{p.v.}$ in Arc
					mm	″	mm	″
3418	1916 Nov. 21	1.0	−0.916	−393	+0.0144	+0.03	+0.0301	+0.05
3419	Nov. 21	1.0	− .916	−393	+ .0148	+ .02	+ .0306	+ .04
3437	Nov. 26	1.0	− .919	−388	+ .0148	+ .01	+ .0346	− .05
3438	Nov. 26	1.0	− .919	−388	+ .0148	+ .01	+ .0306	+ .04
4166	1917 July 4	1.0	+ .743	−168	+ .0204	− .06	+ .0358	− .07
4167	July 4	1.0	+ .743	−168	+ .0146	+ .06	+ .0318	+ .02
4168	July 4	1.0	+ .743	−168	+ .0176	.00	+ .0314	+ .02
4696	Nov. 4	1.0	− .853	− 45	− .0159	+ .04	+ .0335	− .02
4697	Nov. 4	0.8	− .853	− 45	− .0137	.00	+ .0309	+ .03
4701	Nov. 5	1.0	− .859	− 44	− .0088	− .11	+ .0326	.00
4702	Nov. 5	1.0	− .859	− 44	− .0114	− .06	+ .0359	− .07
4727	Nov. 7	1.0	− .870	− 42	− .0146	.00	+ .0366	− .08
4728	Nov. 7	1.0	− .870	− 42	− .0128	− .04	+ .0326	.00
5511	1918 July 2	1.0	+ .764	+195	− .0144	.00	+ .0320	+ .02
5512	July 2	0.7	+ .764	+195	− .0097	− .08	+ .0365	− .06
5513	July 2	0.5	+ .764	+195	− .0185	+ .06	+ .0275	+ .08
5570	July 20	0.8	+ .565	+213	− .0228	+ .08	+ .0312	+ .03
5609	Aug. 6	0.8	+ .330	+230	− .0210	− .04	+ .0350	− .04
5871	Nov. 3	0.8	− .846	+319	− .0504	+ .08	+ .0343	− .02
5903	Nov. 7	1.0	− .869	+323	− .0482	+ .03	+ .0310	+ .04
5970	Nov. 14	0.8	− .899	+330	− .0480	.00	+ .0329	.00
5971	Nov. 14	1.0	−0.899	+330	−0.0462	−0.03	+0.0314	+0.03

The normal equations are:

	Star A	Star C
$20.2c - 3.634\,\mu - 7.2016\pi$	$= -0.2017$mm	$= +0.6621$mm
$+124.9731\mu + 7.3057\pi$	$= -0.9858$mm	$= -0.1085$mm
$+13.7318\pi$	$= +0.1622$mm	$= -0.2349$mm

from which

	Star A	Star C
μ	$= -0''.671$ per year	$= +0''.006$ per year
π	$= +0''.267 \pm 0''.011$	$= +0''.001 \pm 0''.010$

Since the stars A and B form a physical system, their parallaxes should be the same. Their values differ by $0''.002$. Combining the results, the parallax for AB becomes $+0''.266 \pm 0''.009$.

The values determined for the principal star A are: BARNARD by micrometer $0''.249 \pm 0''.010$, SCHLESINGER by photography with Yerkes refractor $0''.252 \pm 0''.006$, and RUSSELL by photography $0''.258 \pm 0''.019$. These values combined with the McCormick result give the parallax $+0''.256 \pm 0''.006$. This parallax is relative to the system of comparison stars chosen. The absolute parallax is $+0''.261$.

The star C has a relative parallax $+0''.001 \pm 0''.010$ and a negligible proper-motion. C has a magnitude nearly equal to each of the five comparison stars, so that, as we should expect, it is relatively fixed with respect to these comparison stars.

It will be shown below that measures up to 1919 indicate that the orbit of AB is intermediate between RUSSELL's orbits B and C, so that the period is nearly 50 years and $a = 2''.68$. The distance AB is accordingly 10.2 astronomical units, and the mass of the system is 0.42 times the *Sun's* mass.

It will be noticed that the proper-motion in right ascension, or $\mu a \cos\delta$, for the star A is $-0''.671$ while that for the companion star B is $-0''.946$, the considerable difference being due to orbital motion. According to PORTER, the proper-motion of the center of gravity is $-0''.797$, but unfortunately this value is very uncertain since the star has been under observation (except for one rather weak measure) only since 1898. It will be necessary for another twenty-five years to elapse before the proper-motion of the center of mass is known with any high degree of precision. The proper-motions of A and B differ from PORTER's value of the center of mass by $-0''.126$ and $+0''.149$, respectively. The masses of B and A must therefore be in the ratio of $126 : 149$, or approximately $5 : 6$. It should be clearly understood that, due to the great uncertainty in the proper-motion of the center of gravity, this ratio should be regarded merely as a rough approximation. From measures of AC, RUSSELL finds the masses B/A as 0.56 and 0.35 from two different solutions. After the lapse of a comparatively few years, by continuation of the measures AC, it will be possible to determine the ratios of the masses with a much higher degree of precision.

Assuming the masses A to B are as $2 : 1$, then the mass of A is two-sevenths that of the *Sun*, and B one-seventh. As RUSSELL has remarked (*loc. cit.*) the fainter companion is the smallest mass assigned with any considerable degree of accuracy to any visible star. Although the mass is one-seventh of the *Sun's*, the luminosity is only 1/2500 that of the *Sun*. This luminosity is about equal to that possessed by BARNARD's Star of Large Proper-Motion, so that intrinsically these two stars are among the faintest stars yet known to astronomy.

PHOTOGRAPHIC MEASURES OF *KRUEGER* 60 AS A DOUBLE STAR,

BY S. A. MITCHELL AND C. P. OLIVIER.

In view of the very excellent series of measurements of position and distance of *Krueger* 60 made by PROFESSOR BARNARD this seemed an excellent star to use as a test object for comparing the accuracy of measures from photographs with those made directly at the telescope by means of the micrometer.

On one photograph of the series of plates of *Krueger* 60 a bright star was allowed to trail. This trail was transferred to each of the other plates by superposing the star images on a plate compared with the standard plate, and marking a trail in ink on the glass side of the plate. This method permitted a quick orientation of the plate in the measuring machine and introduced errors in position angle purely accidental amounting to not more than half a degree. The measures were made in X and Y coördinates from which the position angles and distances were calculated. The additional plates in 1919 were taken by MITCHELL who also measured the relative positions of the stars AB, AC and BC. AB only was measured by OLIVIER.

POSITION ANGLES AND DISTANCES OF *Krueger* 60

Plate	Date	*A* and *B* Mitchell		Olivier		Mean		*A C*		*B C*	
		°	"	°	"	°	"	°	"	°	"
3418	1916.891	62.1	2.43	59.2	2.35	60.6	2.39	59.1	51.71	59.0	49.28
3419	.891	59.0	2.33	60.2	2.41	59.6	2.37	59.6	51.68	59.6	49.35
3437	.905	62.2	2.48	....	....	62.2	2.48	59.4	51.77	59.3	49.28
3438	.905	60.9	2.46	61.1	2.32	61.0	2.39	58.8	51.72	58.8	49.27
Means	1916.898	61.06	2.42	60.17	2.36	60.67	2.40	59.25	51.72	59.17	49.30
4166	1917.507	57.6	2.20	57.6	2.31	57.6	2.26	59.3	51.69	59.4	49.41
4167	.507	56.3	2.27	57.4	2.41	56.8	2.34	59.0	51.70	59.1	49.43
4168	.507	56.3	2.27	57.0	2.42	56.6	2.34	59.1	51.75	59.2	49.47
Means	1917.507	56.75	2.25	57.33	2.38	57.04	2.31	59.13	51.71	59.23	49.44
4696	1917.844	55.2	2.10	55.2	2.20	55.2	2.15	59.4	52.44	59.5	50.39
4697	.844	53.9	2.13	54.2	2.17	54.0	2.15	58.6	52.47	58.8	50.23
4701	.847	54.2	2.11	53.2	2.20	53.7	2.16	59.1	52.80	59.3	50.22
4702	.847	52.7	2.26	53.4	2.16	53.0	2.21	59.1	52.43	59.4	50.19
4727	.852	52.6	2.13	54.2	2.22	53.4	2.18	59.1	52.42	59.4	50.29
4728	.852	54.0	2.23	54.4	2.32	54.2	2.28	59.4	52.44	59.6	50.21
Means	1917.847	53.77	2.16	54.10	2.21	53.94	2.18	59.12	52.50	59.34	50.26
5511	1918.501	48.9	1.95	49.4	1.87	49.2	1.91	59.0	52.46	59.4	50.50
5512	.501	50.0	2.09	49.2	2.02	49.6	2.06	59.0	52.48	59.4	50.42
5513	.501	50.3	2.11	49.4	2.08	49.8	2.10	58.9	52.53	59.2	50.42
5569	.550	50.0	2.11	49.0	2.14	49.5	2.12	59.4	52.72	59.8	50.64
Means	1918.512	49.78	2.06	49.25	2.03	49.52	2.04	59.08	52.55	59.45	50.50
5870	1918.841	47.0	2.01	46.2	2.08	46.6	2.04	59.5	53.07	60.0	51.14
5871	.841	46.1	2.14	46.4	2.23	46.2	2.18	59.2	53.28	59.8	51.22
5903	.852	45.4	2.14	45.1	2.30	45.2	2.22	59.4	53.22	59.9	51.15
5904	.852	45.0	2.15	46.6	2.20	45.8	2.18	59.1	53.26	59.7	51.18
5971	.871	45.9	2.04	46.7	2.18	46.3	2.11	58.9	53.30	59.5	51.36
Means	1918.851	46.10	2.10	46.20	2.20	46.15	2.15	59.22	53.28	59.98	51.21
7849	1919.744	38.4	1.87	36.2	1.84	37.3	1.86	59.7	53.76	60.4	52.14
7850	.744	39.9	1.82	37.9	1.86	38.9	1.84	59.8	53.70	60.5	52.05
7851	.744	38.5	1.86	39.6	1.91	39.0	1.88	59.3	53.74	60.0	51.98
7946	.799	37.7	1.83	34.4	1.99	36.0	1.91	59.1	53.80	59.8	52.10
7947	.799	36.7	1.87	35.6	1.90	36.2	1.88	59.1	53.76	59.9	52.04
Means	1919.777	38.4	1.85	36.7	1.90	37.5	1.87	59.40	53.75	60.12	52.06

The scale of the photographs is $1^{mm} = 20''.8$, so that in 1919 *A* and *B* were separated on the photographs 0.09 millimeters.

For purposes of comparison, PROFESSOR BARNARD has kindly sent his micrometer measures made on this interesting pair between the years 1916 and 1919 inclusive. In making this comparison it should be borne in mind that it is probably more difficult to measure *AC* and *BC* accurately with a great telescope like the 40-inch than it is to accomplish this on a photograph. In measuring a double star, the observer must make the two wires bisect each of the stars at the instant of observation and it becomes difficult to see both wires at the same time when the

distances are as great as nearly 1′, as is the case with AC and BC. On the other hand, due to the small distances separating the centers of the star images A and B on the photographs, this is a more difficult object on the photographs than it is with the micrometer.

As a result of the comparisons between micrometric and photographic measures the following conclusions can be drawn:

(1) BARNARD's measures of the wide pairs AC and BC agree among themselves and are quite as accurate as the measures from the photographs.

(2) In spite of the small distance separating the stars AB and of the difference in magnitude of the components which exceeds 1.5 magnitudes, this star should be classed as an "easy" object to measure on the photographs.

(3) The photographic measures of AB are quite as accordant as the very excellent measures of PROFESSOR BARNARD.

(4) There is no evidence of any systematic errors whatever in the photographic measures, the position angles and distances being quite as accurate as if made with the micrometer attached to the 26-inch McCormick refractor.

(5) The measures of AB compared with RUSSELL's ephemeris show that the distances measured in 1918 and 1919 agree quite closely with orbit B of period 46.0 years, while the position angles follow orbit C with period 54.9 years, indicating a period approximating 50 years.

(6). The ephemeris shows that it will be possible to continue to measure AB on the photographs through periastron.

The above is a small part only of the measures of doubles made from the McCormick photographs. The measures by OLIVIER of 95 doubles, 32 being new discoveries separated by less than 5″, is now in press and will soon appear as a *Publication of the Leander McCormick Observatory.*

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OBSERVATIONS OF VARIABLE STARS,

BY WILLIAM DOBERCK.

(Continued from *A. J.* 765.)

RZ Cygni: The H. C. comparison stars were used and also p (*A. S. V.* 65) 11.20, g (69) 11.37, and r (75) 11.71, which were determined here. The value of the step is 0.082 mag. Individual maxima were observed at 0718 (9.9), 1255 (10.1), and at 1812 (9.8). The average maximum occurred at 242 1262 (9.9). The period appears to have increased.

0347	$p\ 1\ v$	11.3	1040	$r\ 3\frac{1}{2}\ v$	12.0	1525	$q\ 1\frac{1}{2}\ v\ 3\ r$	11.5	1894	$v\ 1\ p$	11.1
0361	$v = m$	10.9	1049	$r\ 3\ v$	12.0	1539	$q\ 2\ v$	11.5	1901	$p\ 2\ v\ 1\ r$	.5
0374	$m\ 2\ v\ 1\ n$	11.0	1067	$r\ 5\ v$	12.1	1568	$q\ 2\ v\ 2\ r$	11.5	1920	$p\ 2\ v$	.4
0387	$v = q$	11.4	1075	$r\ 3\frac{1}{2}\ v$	12.0	1777	$v\ 1\ h$	9.9	1951	$r\ 1\ v$	.8
0432	$p\ 3\ v\ 1\ q$	11.3	1255	$h\ 2\ v$	10.2	1783	$h\ \frac{1}{2}\ v\ 3\ k$	10.0	2096	$n\ 1\ v$	.2
0655	$r\ 5\ v$	12.1	1357	$k\ 3\ v\ 1\ l$	10.6	1793	$v\ 2\ h$	9.8	2098	$n\ 2\ v = p$	.2
0691	$h\ 3\ v\ 1\ k$	10.3	1377	$n\ 3\ v\ 2\ p$	11.2	1812	$f\ 5\ v\ 2\ g$	9.7	2101	$n\ 2\ v\ 1\ p$.	.2
0709	$f\ 3\ v\ 2\ g$	9.7	1384	$v = p$	11.2	1820	$h\ 1\ v$	10.1	2107	$n\ 2\ v\ 1\ p$	.2
0717	$h\ 3\ v$	10.2	1394	$k\ 1\ v\ 1\frac{1}{2}\ l$	10.5	1827	$g\ 3\ v\ 1\frac{1}{2}\ h$	9.9	2115	$v = p$	.2
0725	$v = h$	10.0	1411	$k\ 1\ v\ 2\ l$	10.5	1838	$v\ 1\frac{1}{2}\ h$	9.9	2123	$n\ 1\ v\ 1\ p$	.1
0747	$g\ 3\ v\ 2\ k$	10.2	1432	$n\ 2\ v$	11.3	1844	$h\ 1\ v\ 4\ k$	10.1	2155	$r\ 2\ v$	.9
0761	$h\ 3\ v$	10.2	1457	$p\ 2\ v\ 1\ r$	11.5	1852	$h\ 2\ v$	10.1	2177	$r\ 3\ v$	12.0
0777	$l\ 2\ v\ 2\ m$	10.8	1474	$p\ 3\ v\ 3\ r$	11.5	1864	$k\ 1\ v\ 2\ l$	10.5	2180	$r\ 3\ v$	.0
0785	$m\ 3\ v$	11.2	1486	$p\ 2\ v\ 4\ q$	11.3	1874	$p\ 1\ v\ 3\ n$	11.1	2186	$r\ 3\ v$	.0
0799	$p\ 3\ v\ 3\ n$	11.2	1499	$p\ 3\frac{1}{2}\ v\ 1\ q$	11.3						

U Bootis: The H. C. comparison stars were used. The value of the step is at 10.0 mag. : 0.055 mag., at 10.5 : 0.067, at 11.0 : 0.082, at 11.5 : 0.101. The following maxima were observed 0952 (9.9), 1080 (10.1), 1353 (10.1), 1744 (10.45), and 1836 (10.0), and the minima 0675 (11.05), 1020 (11.4), and 1787 (11.6). The formula for the maxima is 2421466 + 177.*SE*. Minimum occurred on an average 109 days after maximum but the shape of the curve varies. The period is not constant. This is a very irregular, though to some extent periodic, variable star.

0596	*v* 2 *k*	10.83	1067	*v* = *g*	10.36	1411	*l* 3 *v*	11.44	1827	*f* 2 *v* 3 *g*	10.29
0625	*h* 3 *v* 1 *k*	.88	1070	*v* = *f*	.24	1416	*v* = *l*	.18	1828	*g* 1 *v*	.42
0654	*v* = *k*	.99	1075	*e* 2 *v* 1 *f*	.14	1429	*k* 2 *v*	.15	1830	*v* 1 *e*	9.90
0694	*v* = *k*	.99	1084	*f* 1½ *v* 1½ *g*	.30	1710	*h* 4 *v* 3 *k*	10.80	1843	*v* = *c*	9.95
0711	*h* 2 *v* 5 *k*	.67	1096	*v* = *f*	.24	1722	*h* 3 *v* 1 *k*	.88	1847	*v* = *g*	10.36
0725	*v* = *h*	.54	1120	*h* 2 *v* 3 *k*	.72	1723	*k* 1 *v* 2 *l*	11.05	1856	*g* 1 *v*	10.42
0931	*v* = *h*	.54	1311	*v* = *g*	.36	1731	*h* 2 *v* 3 *k*	10.72	1862	*h* 3 *v* 3 *k*	.76
0952	*v* 1 *e*	9.90	1317	*h* 4 *v* 3 *k*	.80	1741	*v* 1 *h*	.47	1865	*h* 2 *v* 3 *k*	.72
0965	*v* = *h*	10.54	1328	*f* 1 *v* 1 *g*	.30	1744	*v* 1½ *h*	.44	2078	*h* 1½ *v* 3 *k*	.69
0969	*h* 4 *v* 3 *k*	.80	1339	*f* 3 *v* 3 *g*	.30	1745	*g* 2 *v* 1 *h*	.48	2093	*h* 2 *v* 3 *k*	.72
0977	*g* 3 *v* 1 *h*	.50	1342	*f* 1 *v* 3 *g*	.27	1746	*g* 1½ *v*	.46	2096	*h* 3 *v* 1 *k*	.88
0983	*v* = *k*	.99	1348	*c* 3 *v* 1 *f*	.17	1758	*h* 1 *v* 2 *k*	.69	2107	*h* 2 *v* 4 *k*	.69
0984	*h* 4 *v* 2 *k*	.84	1350	*c* 2 *v* 3 *f*	.07	1761	*v* 1 *k*	.91	2113	*h* 2 *v* 1 *k*	.84
0992	*k* 2 *v* 3 *l*	11.07	1363	*f* 2½ *v* 1½ *g*	.32	1768	*k* 3 *v* 3 *l*	11.09	2117	*h* 1 *v*	.61
1000	*v* = *l*	.18	1375	*e* 1 *v* 2 *f*	.05	1777	*l* 5 *v* 3 *m*	.60	2121	*g* 2 *v* 2 *k*	.67
1012	*l* 2 *v* 4 *m*	.41	1377	*v* = *g*	.36	1784	*l* 3 *v* 2 *m*	.59	2124	*h* 3 *v* 3 *k*	.76
1036	*l* 1 *v* 3½ *m*	.33	1384	*g* 1 *v*	.43	1793	*l* 3 *v* 1 *m*	.69	2126	*h* 3 *v* 1 *k*	.88
1049	*v* 1 *k*	10.91	1391	*v* = *k*	.99	1804	*h* 3 *v* 2 *k*	10.81	2131	*v* 1 *k*	.91
1064	*e* 2 *v* 3 *f*	.07	1394	*v* = *k*	.99	1826	*v* 1 *f*	.19	2136	*v* 2 *k*	.83

RT Lyræ: Graff's comparison stars have been used. The adopted magnitudes are *a* 10.2, *b* 10.3, *f* 10.7, *e* 11.0, *c* 11.1, *g* 11.3, *m* 11.4, *k* 11.7, *h* 12.0, *n* 12.3. The value of the step is 0.075 mag. Maximum (10.0 − 10.4) occurs at 2421 211 +250.5 E.

0446	*v* 4 *c*	10.7	1188	*b* 2 *v*	10.4	1727	*a* 1 *v* 1 *b*	10.2	2192	*f* 3 *v* 3 *c*	10.9
0468	*b* 3 *v* 5 *f*	10.5	1190	*v* 2½ *a*	10.0	1730	*a* 2 *v* 1 *b*	10.3	2198	*b* 2 *v* 1 *f*	10.6
0654	*v* = *c*	11.1	1192	*v* 2 *a*	10.0	1741	*f* 3 *v* 3 *c*	10.9	2210	*b* 2 *v* 3 *f*	10.5
0664	*b* 3 *v* 3 *f*	10.5	1194	*v* 1½ *a*	10.1	1743	*c* 2 *v* 3 *m*	11.2	2211	*b* 1 *v*	10.4
0749	*c* 3 *v* 1 *m*	11.3	1202	*v* 2 *a*	10.0	1745	*f* 5 *v* 2½ *c*	11.0	2212	*b* 2 *v* 4 *f*	10.4
1168	*v* 2 *c*	11.0	1206	*v* 3 *a*	10.0	1758	*v* = ½(*h* + *k*)	11.8	2218	*b* 3 *v* 3 *f*	10.5
1170	*v* 2 *c*	10.9	1207	*v* 2 *a*	10.0	1760	*m* 4 *v* 6 *n*	11.8	2223	*v* 1 *f*	10.6
1181	*v* = *f*	10.7	1220	*c* 1 *v*	11.2	1761	*m* 3 *v*	11.7	2230	*v* 3 *c*	10.9
1184	*a* 2 *v* 1 *f*	10.5	1507	*k* 1 *v* 6 *n*	11.8	1767	*h* 3 *v*	12.2	2231	*v* ½ *c*	11.1
									2234	*v* = *c*	11.1

X Ophiuchi: The H. C. comparison stars were used. Their brightness observed in steps and converted into magnitude on the H. C. scale is as follows: *a* 6.56, *d* 7.11, *c* 7.23, *b* 7.32, *e* 7.88, *f* 8.34, and *g* 8.90. The value of the step is 0.106 mag. Maxima were observed at 1129 (6.7), 1468 (6.6), 1797 (6.4), and at 2127 (6.5). Maximum (6.55) occurs at 2421798 + 335.4*E*. Minimum (8.6) has not been well observed. It occurs about 145 days after maximum. The curve is nearly symmetrical as may be seen from the formula:

$$\text{Mag.} = 7.72 - 0.92 \cos(x + 5^\circ) - 0.16 \cos(2x - 27^\circ) - 0.06 \cos(3x + 18^\circ) - 0.03 \cos 4x - 0.02 \cos 5x$$

0342	*v = e*	7.9	1012	*e* 3 *v* 2 *f*	8.2	1484	*v = a*	6.6	1905	*f* 3 *v* 2 *g*	8.7
0352	*e* 1 *v*	8.0	1031	*e* 2½ *v* 3½ *f*	8.1	1493	*a* 3 *v* 2½ *d*	6.9	1907	*f* 1 *v* 4 *g*	8.5
0370	*d* 5 *v* 3 *e*	7.6	1049	*e* 1 *v* 3 *f*	8.0	1504	*d* 2 *v = c*	7.3	1913	*e* 3 *v* 5 *g*	8.3
0381	*d* 1 *v* 5 *e*	7.2	1067	*c* 4 *v* 3 *e*	7.6	1507	*d* 2 *v* 1 *c*	7.2	1925	*f* 3 *v* 3 *g*	8.6
0391	*d* 1 *v* 2 *c*	7.1	1070	*b* 3 *v* 3½ *f*	7.8	1522	*b* 5 *v* 2 *e*	7.7	1944	*f* 2 *v* 3 *g*	8.6
0396	*c* 2 *v* 2 *b*	7.3	1080	*b* 1 *v*	7.4	1537	*e* 3 *v* 3 *f*	8.1	2093	*d* 1½ *v*	7.3
0399	*d* 1 *v* 5 *e*	7.2	1109	*v* 4 *c*	6.8	1547	*v* 2 *e*	7.7	2096	*c* 1 *v* 1 *d*	7.2
0438	*a* 4 *v* 7 *d*	6.8	1113	*a* 3 *v* 3 *d*	6.8	1565	*e* 3 *v* 4½ *f*	8.1	2098	*v* 1 *d*	7.0
0451	*a* 4 *v* 7 *d*	6.8	1125	*a* 1 *v* 5 *d*	6.6	1727	*b* 2 *v* 3 *e*	7.5	2099	*v* 2 *d*	6.9
0468	*a* 4 *v* 5 *e*	6.9	1132	*a* 1½ *v*	6.7	1732	*v = b*	7.3	2101	*v* 2 *d*	6.9
0653	*e* 3 *v*	8.2	1158	*v* 2 *d*	6.9	1745	*b* 3 *v* 5 *e*	7.5	2107	*a* 3 *v* 2 *d*	6.9
0664	*c* 3 *v = f*	8.3	1170	*d* 3 *v* 3 *b*	7.2	1760	*b* 1 *v* 5 *e*	7.4	2115	*a* 1 *v* 3 *d*	6.7
0679	*e* 1 *v* 3 *f*	8.0	1181	*b* 2 *v* 3 *e*	7.5	1767	*v* 1 *d*	7.0	2117	*a* 2½ *v* 2 *d*	6.9
0694	*d* 3 *v* 4 *e*	7.4	1184	*b* 3 *v* 3 *e*	7.6	1777	*v* 1½ *d*	6.9	2118	*a* 2 *v* 2 *d*	6.8
0708	*d* 1 *v* 4 *e*	7.3	1190	*b* 3 *v*	7.6	1787	*v* 1 *a*	6.5	2119	*v* 1 *a*	6.4
0723	*d* 2 *v* 4 *e*	7.4	1206	*v* 3 *e*	7.6	1793	*v* 2½ *a*	6.3	2121	*a* 1 *v*	6.7
0736	*v* 2 *d*	6.9	1348	*e* 2 *v = f*	8.2	1812	*v* 3 *d*	6.8	2123	*a* 2 *v* 5 *d*	6.7
0748	*v* 3 *d*	6.8	1363	*e* 1 *v* 3 *f*	8.0	1824	*v* 1 *d*	7.0	2124	*v* 2 *a*	6.4
0760	*v* 3 *d*	6.8	1377	*e = v*	7.9	1843	*v = d*	7.1	2126	*v* 2 *a*	6.3
0774	*a* 3 *v* 4 *d*	6.8	1391	*c = v*	7.9	1860	*b* 3 *v* 5 *e*	7.5	2128	*v* 2 *a*	6.4
0784	*a* 4 *v* 4 *c*	6.9	1429	*d* 3 *v* 1 *c*	7.2	1873	*v* 1 *e*	7.8	2131	*v* 1 *a*	6.4
0799	*v* 3 *d*	6.8	1450	*v* 3½ *d*	6.7	1875	*v* 1 *e*	7.8	2136	*v* 2 *a*	6.4
0979	*c* 5 *v* 3 *f*	8.2	1459	*a* 3 *v* 5 *d*	6.8	1880	*v* 2 *e*	7.7	2155	*a* 3 *v* 3 *d*	6.8
0992	*e* 3 *v* 1 *f*	8.2	1473	*v* 4 *d*	6.7	1900	*e* 2 *v* 1½ *f*	8.1	2176	*d* 1 *v*	7.2

S Aquilæ: The comparison stars were: *a* (*A. S. V.* 27) 9.35, *b* (31) 9.72, *c* (34) 9.97, *d* (39) 10.10, *e* (41) 10.32, *f* (44) 10.40, *g* (49) 10.60, *h* (50) 10.69, *k* (53) 10.99. The magnitudes have been determined at the H. C. with the exception of *e* and *k*, which have been determined here. The value of the step is 0.10 mag. *S Aquilæ* appears to be now an irregularly variable star.

0355	*g* 1 *v = h*	10.7	0779	*h* 3½ *v* 5 *k*	.8	1170	*a* 2 *v*	.55	1787	*a* 4 *v* 1½ *h*	.3
0357	*v = h*	.7	0784	*a* 4 *v* 3 *e*	9.9	1181	*a* 5 *v* 3 *e*	10.0	1793	*a* 3½ *v* 2 *h*	.2
0361	*v* = ½(*h* + *k*)	.8	0788	*a* 3½ *v* 3½ *d*	.7	1184	*a* 2 *v* 3 *h*	9.9	1796	*a* 3½ *v* 1 *h*	.4
0362	*v = h*	.7	0791	*a* 3 *v*	.65	1194	*e* 2 *v* 2 *h*	10.5	1815	*v = h*	.7
0375	*a* 3 *v* 3 *h*	.0	0799	*a* 4 *v* 4 *e*	.8	1206	*a* 5 *v* 3 *e*	10.0	1820	*a* 4 *v* 2 *e*	.0
0391	*a* 1½ *v*	9.5	0807	*a* 3 *v*	9.65	1207	*a* 5 *v*	9.85	1824	*a* 4 *v* 2 *h*	.2
0403	*a* 1 *v*	.45	1036	*a* 3 *v* 3½ *e*	.8	1416	*v* 1 *a*	.25	1827	*a* 4 *v* 2 *e*	.0
0424	*v* 1½ *a*	.2	1049	*e* 1 *v* 1 *h*	10.5	1432	*v* 1 *a*	.25	1828	*a* 3 *v* 2 *e*	9.9
0465	*v* 3 *c*	.7	1063	*k* 2 *v*	11.2	1435	*v* 1 *a*	.25	1830	*a* 3½ *v* 2 *e*	10.0
0506	*a* 4 *v*	.75	1064	*k* 2 *v*	11.2	1450	*a* 2 *v* 2 *c*	.65	1838	*a* 2 *v* 4 *e*	9.7
0664	*v* 1 *c*	.9	1075	*h* 2 *v* 3 *k*	10.8	1459	*a* 3 *v* 2 *c*	9.7	1843	*a* 2 *v*	.55
0684	*a* 5 *v*	.85	1076	*v* 1 *h*	.6	1475	*h* 3 *v* 3 *k*	10.8	1844	*a* 1½ *v*	.5
0708	*a* 4 *v* 3 *h*	10.1	1084	*v* 1 *h*	.6	1488	*k* 2 *v*	11.2	1847	*a* 2 *v* 3 *h*	.9
0709	*a* 3 *v* 2 *e*	9.9	1096	*c* 1½ *v* 3 *e*	.1	1492	*v* 2 *k*	10.8	1860	*a* 3 *v* 3 *h*	10.0
0710	*a* 4 *v* 2½ *e*	.95	1111	*a* 4 *v*	9.65	1507	*e* 2½ *v*	.6	1864	*a* 5 *v* 2 *h*	.3
0716	*a* 5 *v* 4 *f*	.9	1120	*a* 1 *v*	.45	1520	*h* 2 *v*	.9	1865	*a* 3½ *v* 2½ *h*	10.1
0725	*e* 3 *v* 2 *g*	10.5	1126	*a* 1½ *v*	.5	1525	*v* 2 *e*	.1	1867	*a* 4 *v* 2 *h*	.2
0735	*e* 3 *v*	.6	1134	*v = a*	.35	1539	*a* 3 *v*	9.65	1870	*a* 4 *v* 1 *h*	.4
0746	*e* 5 *v*, *h* 4 *v*	11.0	1140	*v* 2 *a*	.15	1547	*v* 1 *a*	.25	1873	*a* 5 *v* 3 *h*	.2
0749	*h* 5 *v* 3 *k*	10.9	1157	*v* 1 *a*	.25	1576	*a* ½ *v*	.4	1874	*a* 4 *v* 3 *h*	.1
0777	*e* 1 *v*	.4	1163	*a* 2 *v*	.55	1783	*e* 2 *v* 1 *h*	10.6	1875	*a* 4 *v* 3 *h*	.1

1889	*a* 3 *v* 2 *c*	9.7	1919	*a* 4 *v* 2 *c*	.8	2155	*a* 2 *v* 5 *d*	.6	2182	*a* 3 *v*	.65
1905	*a* 3 *v* 3 *b*	.5	1920	*a* 1 *v* 2½ *b*	.5	2176	*a* 2 *v*	.55	2184	*a* 3 *v* = *b*	.7
1906	*a* 3 *v* 1 *b*	.6	1925	*a* 4 *v* 3 *c*	.7	2177	*a* 2½ *v*	.6	2186	*a* 3 *v* 1 *b*	.6
1907	*a* 3 *v* 2 *b*	.6	1935	*c* 1 *v* 4 *h*	10.1	2178	*a* 2½ *v*	.6	2192	*a* 3 *v* 2 *b*	.6
1913	*a* 3 *v* 2 *c*	.7	1944	*a* 4 *v* 3 *c*	9.7	2180	*a* 4 *v*	.75	2198	*a* 3 *v* 1 *b*	.6

PROVISIONAL ELEMENTS FOR COMET 1920 *a* (*COMAS SOLA*),

By LOUIS LINDSEY.

The following provisional elements were computed from the three positions, Comas Sola Jan. 13; H. C. Wilson Jan. 20; Barnard Jan. 24. *Astronomical Journal.*

Time of perihelion July 15.8001, 1920

$$\omega\ 268^\circ\ 12'\ 38''$$
$$\Omega\ 299^\circ\ 13'\ \ 2''\qquad 1920.0$$
$$i\ \ 29^\circ\ 21'\ 13''$$
$$\log q\ 0.14297$$

These elements have not been corrected for the inequality of the intervals between the observations and the residuals for the middle place are O — C,

$$\Delta\lambda = -40'', \Delta\delta - 10''.$$

The constants for the equator are

$$x = r(9.76342)\sin(325^\circ\ 31'\ 11'' + v)$$
$$y = r(9.91594)\sin(191^\circ\ 55'\ \ 0'' + v)$$
$$z = r(9.85112)\sin(238^\circ\ 55'\ \ 8'' + v).$$

Ephemeris

G. M. Noon	h m s	° ′ ″
Mar. 27	6 25 30	+12 9 6
31	6 24 38	+11 29 29
Apr. 4	6 24 22	+10 49 53
8	6 24 41	+10 2 55
12	6 25 33	+ 9 29 7
16	6 26 58	+ 8 59 38
20	6 28 56	+ 8 5 6
24	6 31 25	+ 7 21 8

According to these elements the comet will be nearest to the *Earth* in July, but at that time it is rapidly increasing its southern declination. Its distance then is a little more than one astronomical unit.

The elements of this comet, except for the perihelion distance, bear a close resemblance to those of the comet visible to the naked eye in 1533. That comet was observed by measuring its distance from the *Sun* four times and the value of log *q* was given as from 9.303 to 9.514 the latter being by Olbers.

When the elements of the present comet are computed more definitely, a comparison of the elements of the two comets will be worthy of attention.

Syracuse University.

ELEMENTS OF THE *COMAS-SOLA* OBJECT,

By FRANK E. SEAGRAVE.

$$E = 1920,\ \text{Jan.}\ 24.824 \qquad \log a = 0.41554$$
$$M = 347^\circ\ 54'\ 28'' \qquad \log q = 0.35668$$
$$\pi = 135^\circ\ \ 9'\ 23'' \qquad \log e = 9.10295$$
$$\Omega = 300^\circ\ \ 5'\ \ 9'' \qquad \mu = 844''.70$$
$$i = 17^\circ\ 13'\ 17''$$

These elements are based upon three observatoins by Prof. Barnard on Jan. 21, 24, and 29, 1920, of which the first was photographic. The elements are only approximate, as the positions are close together. There is no doubt that the object is an asteroid, and not a comet as announced.

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OBSERVATIONS ON VARIABLE STARS (SUMMARY OF RESULTS),

By WILLIAM DOBERCK.

(Continued from A. J. 767).

RW Aquilæ: The magnitudes of the H. C. comparison stars were used, and also *e′* (*A. S. V.* 38) 9.11, which was compared here. The value of a step is 0.12 mag. The maximum (9.31) occurred 0.15 day before the time according to the formula adopted by Hartwig in 1913. The average magnitude of the star is 9.39. The probable error of an observation including changes in the brightness of the star is 0.087 mag. — The number of days since maximum, the average magnitude, and the number of observations (in parenthesis) are as follows: 0.5 9.40 (12), 1.3 9.37 (8), 2.0 9.39 (11), 2.7 9.45 (7), 3.3 9.36 (6), 3.8 9.41 (7), 4.4 9.33 (7), 5.3 9.42 (7), 5.9 9.40 (11), 66 9.42 (8), 7.2 9.44 (11), 7.7 9.31 (12).

0344.44	e′ 3 v 1 g	9.57	1049.45	v = f	9.30	1520.35	f 2 v 3½ g	9.45	1889.28	f 1 v	9.42
0352.44	e′ 2½ v 2 g	.45	1070.43	f 1 v 3 g	.40	1525.38	v = f	.30	1899.32	f 1½ v 3 g	.44
0355.44	f 2 v = g	.63	1075.43	f 3 v 1 g	.62	1539.30	f 3 v 2 g	.55	1905.24	f 2 v 3 g	.47
0357.38	v = f	.30	1076.40	v 1 f	.18	1547.26	f 2½ v 3 g	.49	1906.24	f 2 v 1 g	.58
0358.36	f 1 v 2 g	.44	1084.40	f 2 v 3 g	.47	1576.23	f 1 v	.42	1907.24	f = v	.30
0361.41	e 6 v 3½ f	.03	1096.42	e 4 v 2 f	.06	1783.46	f 1 v 2 g	.44	1913.24	f = v	.30
0362.40	v = f	.30	1111.43	e′ 1 v 2 f	.17	1787.43	f 1½ v 2½ g	.37	1919.22	v = f	.30
0370.37	f 1 v 2 g	.44	1120.34	f 1 v 3 g	.40	1793.48	f 2 v	.54	1920.21	f ½ v 3 g	.36
0403.38	f 1 v 3 g	.41	1126.36	f 1 v 2 g	.44	1796.46	f 2 v 1 g	.58	1925.22	v 1 f	.18
0451.26	f 2 v 2 g	.51	1134.35	f 2 v 4 g	.44	1815.48	f 2 v 1 g	.58	1935.26	f 2 v 3 g	.47
0505.23	f 1 v 2 g	.44	1140.39	f 1 v 3 g	.40	1820.43	f 1 v	.42	1944.23	f 1½ v	.48
0664.46	e′ 1 v 1 f	.20	1157.40	v = f	.30	1824.45	f 2 v 1 g	.58	2155.47	f ½ v	.36
0696.43	f 1 v 3 g	.42	1163.29	f 2 v 1 g	.58	1827.36	v = f	.30	2176.38	f 1 v 2 g	.44
0707.39	v = f	.30	1170.26	v = f	.30	1828.35	v 1 f	.18	2177.41	v 1 f	.18
0711.48	f 1 v	.42	1181.29	f 2½ v 2½ g	.51	1830.35	v = f	.30	2178.41	f 1 v 2 g	.44
0725.43	d 5 v 2 f	.09	1184.34	f 2 v 3 g	.47	1838.36	v 1 f	.18	2180.39	f 1 v 2 g	.44
0749.37	e 5 v 1 f	.18	1194.22	e 5 v 2 f	.09	1843.39	f 2 v 1 g	.58	2182.38	v = f	.30
0751.39	f 2 v 2 g	.51	1206.23	v = f	.30	1844.41	f 2 v 1 g	.58	2184.42	f 1 v 3 g	.40
0758.50	f 1 v 3 g	.40	1207.23	f 3 v 2 g	.55	1847.34	f 1 v 3 g	.41	2186.37	v 1 f	.18
0760.31	f 2 v 3 g	.47	1416.43	e 4 v 1 f	.16	1860.38	f 2 v 1 g	.58	2192.38	f 1 v 2 g	.44
0791.27	e 5 v 2 f	.09	1432.48	f 2 v 1 g	.58	1864.37	v 1 f	.18	2245.27	v ½ f	.24
0799.28	f 1 v 3 g	.40	1435.42	f 1½ v 3 g	.44	1865.32	f 1½ v 1 g	.55	2246.28	v 1½ f	.12
0800.35	f 2 v 3 g	.46	1450.46	v ½ f	.24	1867.40	f 1 v 1 g	.51	2247.28	f 1 v 2 g	.44
0801.27	f 2 v 3 g	.46	1459.38	e′ 2 v 2 g	.44	1870.33	f 1 v 1 g	.51	2253.25	v = f	.30
0804.36	f 2½ v 4 g	.46	1475.37	v 1 f	.18	1873.37	f 1 v 2 g	.44	2253.38	f 1½ v	.48
0807.29	f 1 v	.42	1488.36	f 1 v 2 g	.44	1874.40	f 2 v 1 g	.58	2254.25	v = f	.30
1036.51	e′ 3 v 2 g	.48	1507.30	f 2 v 3 g	.47	1875.28	f ½ v 1½ g	.40			

TX Cygni: The H. C. comparison stars were used, their magnitudes being observed in steps and reduced to H. C. scale: *b* 8.26, *b′* (*A. S. V.* 28) 9.02, *c* 9.19, *c′* (*A. S. V.* 27) 9.50, *d* 9.58, *d′* (*A. S. V.* 36) 9.87, *e* 9.91, and *f* 10.23. The value of a step was at 9.0 : 0.11, at 9.5 : 0.10, at 9.7 : 0.08, and at 10.0 : 0.07. — Maximum (8.77) occurred at 2421790.99, and minimum (9.94) at 2421799.95 (8.96 days after maximum). The period, 14.7092 days, is constant.

The observations were arranged according to the time elapsed since preceding maximum, and normal places formed, each being the mean of four or five observations. They were projected and a curve drawn among them. The period being divided into 24 equal parts, the following values of the magnitude were read off beginning with maximum: 8.77, 8.94, 9.00, 9.11, 9.20, 9.27, 9.35, 9.42, 9.49, 9.54, 9.61, 9.69, 9.81, 9.90, 9.935, 9.935, 9.91, 9.87, 9.83, 9.77, 9.70, 9.59, 9.38, 9.00. These figures are represented by the following formula:

$$\begin{aligned}\text{Mag.} = 9.50 &- 0.46 \sin (x + 55°) \\ &- 0.12 \sin (2x + 85°) - 0.09 \sin (3x + 70°) \\ &- 0.05 \sin (4x + 112°) - 0.03 \sin (5x + 108°) \\ &- 0.03 \sin (6x + 135°) - 0.01 \cos 7x \\ &+ 0.01 \sin 7x + 0.01 \sin 8x - 0.01 \cos 9x \\ &+ 0.01 \sin 9x - 0.01 \cos 10x + 0.01 \sin 10x \\ &- 0.01 \cos 11x.\end{aligned}$$

The brightness increases quickly to its maximum, but after that is reached the fall is soon checked and proceeds then regularly. In case of many long period variables the curve shows a more or less pronounced hump after maximum, that sometimes gives rise to a secondary maximum preceded by a slight minimum, but in case of the flash star *VY Cygni* this second maximum is as great as the first maximum, so that there are two flashes with a secondary minimum between them. Many long period variable stars have long continued maxima during which the brightness scarcely varies. This minute similarity of the light curves of the two classes of variable stars indicates that the variation is due to the same cause in both cases.

0347.46 *c′* 1 *v* 1 *d′*	9.68	0749.34 *c* 1 *v* 3 *d*	9.29	1070.47 *b* 4 *v* 2 *c*	8.88	1745.45 *v* = *d*	9.58
0349.39 *v* = *b′*	9.02	0750.39 *c* 3½ *v* 2½ *d*	9.42	1070.48 *b* 5 *v* 3 *c*	8.84	1746.41 *b* 4 *v* 3 *c*	8.79
0356.37 *v* = *d*	9.58	0751.40 *c′* 2 *v* 4 *d′*	9.62	1084.39 *v* 2 *c*	8.97	1760.43 *c* 3 *v* 2 *d*	9.42
0357.36 *c′* 2 *v* 3 *d′*	9.68	0751.40 *c* 3 *v* 2 *d*	9.42	1158.38 *b* 4 *v* 5 *c*	8.67	1761.45 *b* 5 *v* 2 *c*	8.92
0358.35 *d* 1 *v*	9.68	0752.36 *d* 3 *v* 3 *e*	9.74	1188.45 *b* 5 *v* 3 *c*	8.84	1767.49 *d* 2 *v* 3 *e*	9.71
0361.36 *d* 2 *v* 3 *e*	9.71	0753.35 *c′* = *v*	9.50	1202.22 *b* 5 *v* 4 *c*	8.78	1768.43 *d* 3 *v* 2 *e*	9.78
0362.35 *v* = *d*	9.58	0758.49 *d* 2 *v* 2 *e*	9.75	1202.26 *b* 5 *v* 5 *c*	8.72	1770.48 *e* 3 *v* 1 *f*	10.15
0364.36 *b′* 1 *v* 2 *d*	9.21	0760.32 *b′* 3 *v* 2 *c′*	9.31	1202.37 *b* 4½ *v* 4½ *c*	8.72	1777.46 *v* 1½ *c*	9.03
0366.35 *b′* 2 *v* 1 *c*	9.13	0761.30 *b* 5 *v* 3 *c*	8.84	1391.44 *d* 3 *v* 1 *e*	9.83	1778.49 *v* = *c*	9.19
0368.33 *c* 1 *v* 2 *d*	9.32	0761.41 *b* 5 *v* 5 *c*	8.72	1476.34 *e* 1½ *v*	10.01	1781.40 *c* 3 *v* 1 *d*	9.48
0370.41 *c′* 1 *v*	9.60	0770.36 *c′* 2 *v* 2 *d′*	9.68	1503.31 *d* 2 *v* 2 *e*	9.75	1783.44 *d* 1½ *v* 3 *e*	9.69
0379.40 *v* = *b′*	9.02	0770.36 *e* 3 *v* 3 *f*	10.07	1508.30 *c* 2 *v* 2 *f*	10.07	1784.41 *d* 3 *v* 3 *e*	9.75
0381.33 *v* = *d*	9.58	0775.41 *c* 2 *v* 2 *d*	9.38	1521.37 *v* = *f*	10.23	1787.42 *d* 4 *v* 1½ *e*	9.82
0452.29 *a* 10 *v* 5 *c*	8.70	0777.37 *v* 1 *c*	9.08	1527.30 *v* 2½ *c*	8.92	1793.47 *v* 2 *c*	8.97
0534.25 *e* 6 *v* 4 *f*	9.81	0779.36 *c* 3 *v* 1 *d*	9.48	1532.42 *d* 1 *v* 2 *e*	9.69	1796.44 *v* = *d*	9.58
0654.46 *d* 2½ *v* 1 *e*	9.82	0785.31 *e* 3 *v* 3 *f*	10.07	1540.28 *v* 3 *c*	8.86	1812.38 *d* 3 *v* 2 *c*	9.78
0655.46 *d* 2 *v* 1 *e*	9.80	0788.36 *d* 1 *v* 2 *c*	9.69	1549.32 *v* = *f*	10.23	1820.41 *b* 6 *v* 3 *c*	8.88
0656.45 *c* 3 *v* 1 *d*	9.48	0789.39 *d* 2½ *v* 2½ *e*	9.74	1558.32 *v* 2 *c*	8.99	1826.35 *v* 1 *d*	9.48
0663.42 *c* 4 *v* 2 *d*	9.45	0791.29 *b* 5 *v* 3 *c*	8.84	1565.37 *d* 4 *v* 1½ *e*	9.82	1827.34 *d* 3 *v* 2 *e*	9.78
0665.44 *c′* 1 *v* 2 *e*	9.64	0800.36 *e* 3 *v* 3 *f*	10.07	1566.36 *e* 1½ *v*	9.95	1828.33 *e* 1½ *v* 4 *f*	10.00
0667.42 *e* 2 *v* 3 *f*	10.04	0801.29 *d* 3 *v* 2 *e*	9.78	1568.32 *e* 1 *v* 4 *f*	9.97	1830.33 *e* 2 *v* 1½ *f*	10.09
0670.41 *d* 3 *v* 3 *e*	9.74	0804.37 *v* = *d*	9.58	1576.28 *v* 1 *d*	9.48	1838.32 *d* 1 *v*	9.68
0696.45 *v* = *d′*	9.87	0807.30 *c* 1 *v* 3 *d*	9.29	1727.50 *d* 2 *v* 3 *e*	9.71	1839.41 *c* 1 *v* 2 *d*	9.32
0709.43 *v* = *c′*	9.50	0887.23 *d* 3 *v* 3 *e*	9.75	1730.45 *d* 1½ *v* 2½ *e*	9.70	1843.31 *d* 2 *v* 2 *e*	9.75
0717.34 *b* 5 *v* 5 *c*	8.72	0892.23 *d* 1 *v* 4 *e*	9.65	1732.48 *b* 4 *v* 2 *c*	8.88	1844.39 *d* 3 *v* 1 *e*	9.83
0717.36 *b* 5 *v* 5 *c*	8.73	0899.25 *c* 1 *v* 3 *d*	9.29	1734.44 *c* 1½ *v* 2½ *d*	9.34	1845.33 *v* = *e*	9.91
0717.38 *b* 5 *v* 4 *c*	8.78	0903.25 *c′* 4 *v* 3 *d′*	9.71	1741.45 *v* 1 *e*	9.84	1847.31 *d* 1 *v* 3 *e*	9.66
0746.39 *b′* 1 *v* 5 *c′*	9.10	0903.25 *d* 3 *v* 2 *e*	9.78	1743.47 *v* 2 *e*	9.77	1852.34 *v* 1 *c*	9.08
0748.38 *b′* 1 *v* 2 *c′*	9.18	1070.39 *b* 5 *v* 3 *c*	8.84	1744.44 *d* 3 *v* 2 *c*	9.78	1856.31 *d* 1 *v* 3 *e*	9.66

1860.34 *e* 1 *v*	9.98	1951.33 *v* = *d*	9.58	2126.43 *d* 3 *v* 1½ *e*	9.80	2214.33 *d* 4 *v* 1 *e*	9.84
1862.29 *d* 3 *v* 1½ *e*	9.80	1961.22 *v* 2 *c*	9.77	2127.43 *d* 1 *v* 4 *e*	9.65	2218.37 *v* 1 *c*	9.08
1864.38 *b* 4 *v* 4 *c*	8.72	1970.24 *c* 3 *v* 1½ *d*	9.45	2128.42 *v* 2 *c*	8.98	2219.32 *v* 1½ *c*	9.03
1864.41 *b* 3 *v* 4 *c*	8.66	2093.46 *e* 3 *v* 2 *f*	10.10	2131.44 *v* 1 *c*	9.08	2223.44 *c* 3 *v* 1 *d*	9.48
1865.31 *b* 4 *v* 2 *c*	8.88	2096.47 *v* 1 *e*	9.84	2136.46 *d* 3 *v* 2 *e*	9.78	2230.28 *v* 1 *d*	9.48
1867.42 *v* 1 *c*	9.08	2098.46 *d* 1½ *v* 2 *e*	9.72	2155.39 *d* 2 *v* 3 *e*	9.71	2231.39 *v* 1½ *c*	9.03
1870.33 *c* 4 *v* 1 *d*	9.50	2099.48 *b* 5 *v* 2 *c*	8.92	2176.37 *v* 2 *c*	8.98	2232.27 *b* 5 *v* 5 *c*	8.72
1873.29 *e* 3 *v* 2 *f*	10.10	2100.46 *v* 1 *c*	9.08	2177.39 *v* = *d*	9.58	2232.37 *b* 5 *v* 5 *e*	8.72
1874.43 *e* 2 *v* 3 *f*	10.04	2101.45 *c* 3 *v* 3 *d*	9.38	2178.39 *c* 2 *v* 1 *d*	9.45	2234.40 *c* 1 *v* 2 *d*	9.32
1875.29 *e* 1 *v* 3 *f*	9.99	2102.45 *e* ½ *v* 3 *d*	9.25	2180.38 *d* 1½ *v* 3 *e*	9.69	2242.26 *d* 4 *v* 2 *e*	9.80
1880.28 *b* 6 *v* 2 *c*	8.96	2107.45 *e* 1 *v*	9.98	2182.37 *d* ½ *v*	9.63	2244.45 *v* ½ *e*	9.87
1901.47 *e* 2 *v* 2 *f*	10.07	2115.44 *v* 2 *c*	8.98	2184.41 *d* 1 *v*	9.68	2245.26 *v* 1 *d*	9.48
1906.36 *c* 2 *v* 1 *d*	9.45	2117.45 *c* 1½ *v* 1½ *d*	9.38	2186.35 *c* 3 *v* 2 *d*	9.42	2247.26 *b* 5 *v* 2½ *c*	8.88
1907.38 *c* 2 *v* 1 *d*	9.45	2118.44 *c* 3 *v* 1 *d*	9.48	2187.35 *v* 2 *c*	8.98	2249.25 *v* = *c*	9.19
1913.37 *d* 1½ *v* 3 *e*	9.69	2119.41 *c* 1½ *v* 2 *d*	9.36	2192.37 *c* 1 *v* 2 *d*	9.32	2250.25 *c* 1 *v*	9.30
1920.32 *d* 1 *v* 2 *e*	9.69	2120.41 *d* 1 *v*	9.68	2193.34 *d* ½ *v*	9.63	2251.25 *v* 1 *c*	9.08
1925.33 *v* 2 *c*	8.98	2121.43 *c* 2 *v* 2 *d*	9.39	2198.40 *e* ½ *v*	9.95	2253.25 *d* 2 *v* 2 *e*	9.74
1928.32 *d* 1 *v* 1 *e*	9.74	2123.44 *d* 2 *v* 1 *e*	9.80	2210.39 *e* 2 *v* 2 *f*	10.07	2254.25 *e* 1 *v*	9.98
1935.28 *d* 4 *v* 2 *e*	9.80	2124.41 *d* 1 *v* 3 *e*	9.66	2212.32 *d* 3 *v* 2 *e*	9.78	2258.25 *d* 3 *v* 2 *e*	9.78
1944.30 *d* 3 *v* 2 *e*	9.78	2125.43 *d* 2 *v* 1 *e*	9.80	2213.31 *d* 4 *v* 1 *e*	9.84	2258.40 *d* 2 *v* 3 *e*	9.71

VY Cygni: The H. C. comparison stars were used, their magnitudes being observed in steps and reduced to H. C. scale: *c* 9.11, *d* 9.28, *e* 9.69, *f* 10.06, and *f′* (*A. S. V.* 38) 10.11. The value of the step is 0.074 mag. — Maximum (9.40) occurred at 2421745.36, the first minimum (9.63) 1.15 day later, the second maximum (9.42) 1.95 days after the first maximum, and the principal minimum (9.94) 4.1 days after the mean of the two maxima. Comparing the mean of the maxima with the maximum at 2416370.95 quoted by Hartwig the period is 7.85875, which shows a slight decrease.

The period being divided into 24 equal parts beginning with the mean of the maxima the following values of the magnitude were taken from the light curve: 9.58, 9.58, 9.51, 9.42, 9.57, 9.64, 9.68, 9.71, 9.75, 9.79, 9.83, 9.88, 9.93, 9.93, 9.89, 9.84, 9.79, 9.74, 9.61, 9.47, 9.43, 9.41, 9.47, 9.51. These are represented by the following formula:

$$\begin{aligned}\text{Mag.} = 9.67 &+ 0.22 \sin (x - 85^\circ) \\ &+ 0.06 \sin (2x + 51^\circ) + 0.045 \sin (3x + 117^\circ) \\ &+ 0.04 \sin (4x + 104^\circ) + 0.01 \cos 5x \\ &+ 0.02 \sin 6x + 0.01 \sin 7x - 0.01 \cos 8x \\ &- 0.01 \cos 9x + 0.01 \sin 10x + 0.01 \cos 12x.\end{aligned}$$

0347.47 *e* 5 *v* 2 *f′*	9.99	0534.25 *e* 2 *v* 3 *f*	9.84	0751.41 *e* 3 *v* 3 *f*	9.88	0887.23 *e* 2 *v* 4 *f*	9.81
0349.40 *v* 1 *e*	9.62	0654.46 *d* 5 *v* 3 *e*	9.54	0752.37 *d* 3 *v* 1 *f′*	9.90	0892.24 *e* 1 *v* 2½ *f*	9.80
0352.46 *e* 2 *v* 3 *f′*	9.86	0655.46 *d* 4 *v* 3 *e*	9.51	0753.36 *e* 3 *v* 3 *f*	9.87	0899.26 *e* 2 *v* 2 *f*	9.87
0355.44 *v* = *e*	9.69	0656.46 *e* 2 *v* 3 *f*	9.84	0758.49 *e* 2 *v* 3 *f*	9.84	0903.26 *e* 3 *v* 3 *f*	9.87
0356.38 *v* = *d*	9.28	0663.43 *d* 5 *v* 2 *e*	9.57	0760.33 *e* 3 *v* 2 *f′*	9.94	1040.44 *d* 3½ *v* 2½ *e*	9.52
0357.37 *e* 1 *v* 2½ *f*	9.80	0665.44 *e* 3 *v* 3 *f*	9.87	0761.32 *e* 3 *v* 3 *f*	9.88	1063.39 *d* 2 *v* 3 *e*	9.44
0358.35 *e* 3 *v* 4 *f*	9.85	0667.43 *e* 2 *v* 3 *f*	9.84	0770.36 *d* 3 *v* 1½ *e*	9.55	1070.47 *d* 1 *v* 2 *e*	9.42
0361.37 *v* = *e*	9.69	0670.42 *d* 3 *v* 3 *e*	9.49	0775.40 *e* 3 *v* 3 *f*	9.87	1077.37 *c* 3 *v* 1 *d*	9.24
0362.36 *d* 2 *v* 3 *e*	9.44	0696.43 *e* 3 *v* 3 *f*	9.87	0777.38 *e* 4 *v* 2 *f*	9.94	1078.37 *d* 3 *v* 3 *e*	9.48
0366.35 *e* 2 *v* 1 *f*	9.94	0708.47 *d* 2 *v* 3 *e*	9.44	0779.26 *d* 3 *v* 3 *e*	9.48	1125.36 *d* 3 *v* 2 *e*	9.53
0368.34 *e* 4 *v* 3 *f*	9.90	0709.39 *d* 3 *v* 4 *e*	9.46	0779.29 *d* 4 *v* 5 *e*	9.46	1158.39 *e* 2 *v* 5 *f*	9.80
0370.41 *v* = *d*	9.28	0709.44 *d* 3 *v* 4 *e*	9.46	0779.37 *d* 5 *v* 2 *e*	9.57	1165.32 *d* 3 *v* 1½ *e*	9.55
0371.42 *v* = *d*	9.28	0717.35 *e* 3 *v* 3 *e*	9.40	0785.31 *e* 3 *v* 1 *f*	9.97	1168.29 *e* 3 *v* 4 *f*	9.85
0371.47 *d* 2 *v* 1 *e*	9.55	0717.36 *d* 3 *v* 3 *e*	9.48	0789.40 *v* = *e*	9.69	1181.30 *d* 4 *v* 2 *e*	9.55
0379.41 *v* 1½ *e*	9.58	0717.38 *d* 4 *v* 4½ *e*	9.47	0791.29 *e* 3 *v* 2 *f*	9.91	1188.44 *d* 4 *v* 1 *e*	9.61
0381.38 *e* 1 *v* 3½ *f*	9.77	0741.39 *v* = *c*	9.11	0800.37 *e* 3 *v* 1 *f*	9.97	1202.38 *d* 2 *v* 2 *e*	9.48
0387.32 *d* 4 *v* 1 *e*	9.61	0748.38 *d* 4 *v* 3 *e*	9.51	0801.29 *d* 2 *v* 1 *e*	9.55	1220.23 *d* 3 *v* 2 *e*	9.53
0452.28 *e* 3 *v* 5 *f*	9.83	0749.34 *e* 3 *v* 4½ *e*	9.34	0804.37 *d* 3 *v* 3 *e*	9.48	1391.44 *d* 3 *v* 3 *e*	9.48
0468.33 *e* 4 *v* 5 *f*	9.85	0750.39 *e* 1 *v* 3 *f*	9.78	0807.31 *v* = *f*	10.06	1476.35 *e* 3 *v* 2 *f*	9.91

1508.30 d 5 v 1 e	9.62	1793.47 d 2½ v 4 e	9.44	1925.33 d 4 v 3 e	9.51	2178.39 d 3 v 3 e	9.49
1521.37 e 3 v 2 f	9.91	1796.45 e 2½ v 3 f	9.86	1928.32 v = e	9.69	2180.38 e 2 v	9.84
1527.31 v 1 d	9.21	1812.38 v = e	9.69	1935.28 v 1 e	9.62	2182.37 e 1 v 3 f	9.78
1532.43 e 3 v 1 d	9.24	1820.41 e 1½ v 2 f	9.85	1944.30 e 2 v 3 f	9.84	2184.41 e 1 v	9.76
1540.29 d 3 v 3 e	9.49	1826.35 v 1½ e	9.58	1951.33 d 3 v 2 e	9.53	2186.35 e 1 v	9.76
1549.33 d 2½ v 3 e	9.47	1827.34 v ½ e	9.65	1961.23 d 5 v 2 e	9.57	2187.35 d 5 v 5 e	9.49
1558.32 d 3 v 1½ e	9.55	1828.34 e 2 v 3 f	9.84	2096.47 e 1 v	9.76	2191.37 d 4 v 4 e	9.48
1565.37 d 4 v 2 e	9.55	1830.33 v 1 e	9.62	2098.46 d 1 v	9.35	2193.35 d 3 v 3 e	9.49
1566.36 d 3 v 1½ e	9.55	1838.34 v 1 e	9.62	2099.48 d 3 v 3 e	9.48	2198.40 e 3 v 3 f	9.87
1568.32 e 2 v 2 f	9.88	1839.41 d 2 v 3 e	9.44	2100.47 d 5 v 2 e	9.57	2210.40 d 3 v 2 e	9.53
1576.28 v = e	9.69	1843.31 d 3 v 1 e	9.59	2101.45 v 1 e	9.62	2211.32 v 1½ e	9.58
1727.50 f 2 v	10.21	1844.39 e 1½ v 2½ f	9.83	2102.45 e 2 v 3 f	9.84	2212.32 d 5 v 2 e	9.57
1730.45 v 1 e	9.62	1845.34 e 2 v 2 f	9.88	2107.45 d 5 v 1½ e	9.60	2213.31 e 2 v 2 f	9.87
1732.48 v = e	9.69	1847.31 d 1 v 3 e	9.38	2115.44 d 2 v 3 e	9.44	2214.33 e 3½ v 1½ f	9.95
1734.44 e 2 v 2 f	9.88	1852.35 e 2½ v 1½ f	9.92	2117.45 v = e	9.69	2218.37 d 3 v 1 e	9.61
1741.45 e ½ v 3 f	9.74	1856.31 d 3 v 2 e	9.53	2118.44 e 1 v	9.76	2219.32 e ½ v	9.73
1743.47 e 2 v 3½ f	9.83	1860.34 e 1 v	9.76	2119.42 e 2 v 3 f	9.84	2223.45 e ½ v	9.73
1744.44 v 1½ e	9.58	1862.29 v = e	9.69	2120.41 e 2 v	9.84	2230.28 e 3 v 2 f	9.91
1745.45 d 3 v 2 e	9.54	1864.38 d 5 v 2 e	9.57	2121.43 d 3 v 2 e	9.53	2231.39 e 1 v	9.76
1746.42 e 2 v 4 f	9.81	1865.31 v 1 e	9.62	2123.45 d 3 v 2 e	9.53	2232.28 d 3 v 2 e	9.53
1760.43 d 2 v 3 e	9.44	1867.42 e 2 v 4 f	9.81	2124.41 d 1 v	9.35	2234.42 v 2 e	9.54
1761.45 d 1½ v 5 e	9.37	1870.34 d 2 v 2 e	9.48	2125.43 v 1 e	9.62	2242.26 v 1 e	9.62
1767.49 e 2 v 3 f	9.84	1873.29 d 5 v 3 e	9.54	2126.43 v 1 e	9.62	2244.46 e 2 v 4 f	9.81
1768.43 d 2 v 5 e	9.40	1874.43 e 1½ v 4 f	9.79	2127.43 e 3 v 1 f	9.97	2245.26 e 3 v 3 f	9.88
1770.49 d 2 v 3 e	9.44	1875.29 e 1 v 3 f	9.78	2128.43 e 2½ v 3 f	9.86	2247.26 v 1½ e	9.58
1777.46 d 2½ v 3 e	9.47	1880.28 v = e	9.65	2131.45 d 3 v 1½ e	9.55	2249.25 d 4 v 1½ e	9.58
1778.49 d 3 v 3 e	9.48	1901.48 e 1 v 3 f	9.78	2131.50 d 4 v 2 e	9.55	2249.43 d 4 v 3 e	9.51
1781.40 e 1 v	9.76	1906.36 e 1 v 3 f	9.78	2136.46 v 1 e	9.62	2250.25 d 5 v 2 e	9.57
1783.44 d 4 v 1 e	9.61	1907.38 f 3 v	10.28	2155.39 v 1 e	9.62	2251.25 e 1½ v	9.80
1784.41 d 1½ e	9.39	1913.37 d 4 v 2 e	9.55	2176.37 d 4 v 3 e	9.51	2253.25 e 1 v	9.76
1787.42 v 1 e	9.62	1920.32 d 4 v 2 e	9.55	2177.39 d 1 v	9.35	2254.25 e 3 v 3 f	9.88
						2258.25 v 1½ e	9.58

VZ Cygni: The H. C. comparison stars were used and their magnitudes, observed in steps, reduced to H. C. scale: *d* 8.47, *e* 8.81, *f* 9.30, and *g* 9.55. The value of a step is 0.076 mag. Maximum (8.67) occurred at 2421775.53. The period is 4.86434. It appears to have slightly increased. Minimum (9.08) occurs 3.8 days after maximum. — The following means of about six observations were projected (the first figure shows the time in days counted from maximum, and the second the corresponding brightness): 0.01 : 8.67, 0.17 : 8.68, 0.34 : 8.68, 0.54 : 8.70, 0.72 : 8.76, 0.94 : 8.78, 1.11 : 8.83, 1.24 : 8.82, 1.42 : 8.92, 1.67 : 8.86, 1.84 : 8.96, 1.97 : 8.94, 2.08 : 8.99, 2.23 : 9.00, 2.42 : 8.92, 2.58 : 8.99, 2.85 : 9.04, 2.99 : 8.97, 3.13 : 9.07, 3.34 : 9.08, 3.50 : 9.07, 3.70 : 9.01, 3.87 : 9.03, 3.94 : 9.11, 4.02 : 9.10, 4.10 : 9.03, 4.20 : 8.98, 4.33 : 8.90, 4.36 : 8.81, 4.38 : 8.89, 4.41 : 8.81, 4.46 : 8.88, 4.56 : 8.85, 4.67 : 8.68. By aid of these means the curve was constructed and the following formula derived from twelve readings:

$$\begin{aligned}\text{Mag.} = 8.907 &- 0.181 \sin (x + 49°) \\ &- 0.070 \sin (2x + 69°) - 0.031 \sin (3x + 103°) \\ &- 0.018 \sin (4x + 142°) + 0.007 \sin 5x \\ &+ 0.003 \cos 6x.\end{aligned}$$

0349.43 e 3 v 3 f	9.06	0366.36 e 2 v 3 f	9.01	0374.42 e 2 v 5 f	8.95	0403.42 e = v	8.81
0356.38 v = e	8.81	0368.34 v = f	9.30	0379.41 v = d	8.47	0403.42 v ½ e	8.77
0357.37 e 2 v 2 f	9.06	0371.44 e 1 v 4 f	8.91	0384.32 v = e	8.81	0403.44 v 1 e	8.73
0358.36 e 3 v 2 f	9.10	0374.32 v 1 e	8.73	0398.30 e 4 v 4 f	9.05	0403.45 v 2 e	8.66
0361.37 e 2 v 5 f	8.95	0374.34 e 1 v	8.89	0398.37 e 3 v	9.03	0403.46 e 1 v	8.89
0362.37 e 3 v 3 f	9.06	0374.36 e 1 v 4½ f	8.90	0403.37 e 2 v	8.96	0403.47 e 2 v	8.96

0437.36 e 1 v 5 f	8.89	1084.36 d 3 v 1 e	8.73	1826.34 e 3½ v 4½ f	9.02	2121.43 e 1 v	8.89
0437.42 d 4 v 2 e	8.70	1084.39 e 3 v 4 f	9.02	1827.34 e 2 v	8.96	2123.45 e 2 v 4 f	8.97
0534.28 e 1 v 4 f	8.91	1084.41 v = e	8.81	1828.34 e 3 v 5 f	8.99	2124.45 e 2 v 3 f	9.01
0548.26 e 3 v 2 f	9.10	1158.39 d 3 v 4 e	8.62	1830.34 d 3 v 2 e	8.67	2125.43 e 2 v 5 f	8.95
0654.47 e 2 v 4 f	8.97	1181.30 v 1 f	9.22	1838.34 e 3 v 5 f	8.99	2126.43 v ½ e	8.77
0655.48 e 3 v 4 f	9.02	1202.38 v = e	8.81	1839.41 d 2 v 1 e	8.70	2127.43 e 1 v	8.89
0656.46 e = v	8.81	1220.24 e 3 v 3 f	9.06	1843.31 e 1 v	8.89	2128.43 e 2 v	8.96
0663.46 e 2 v 3 f	9.01	1391.44 d 3 v 2 e	8.67	1844.39 d 2 v 1 e	8.70	2131.45 v 1½ e	8.70
0665.45 e 4 v 2 f	9.14	1476.35 e 2 v 4 f	8.97	1845.34 d 3 v 1 e	8.73	2155.39 d 3 v 1 e	8.72
0667.45 v = e	8.81	1503.32 d 3 v 1½ e	8.70	1847.32 e 2½ v 5 f	8.97	2176.37 e 3 v 5 f	8.99
0670.42 e 3 v 1 f	9.18	1508.30 d 4 v 1 e	8.74	1852.35 e 3 v	9.04	2177.39 e 4 v 4 f	9.06
0696.46 e 1 v	8.89	1517.26 e 2 v 4 f	8.97	1856.31 e 3 v 5 f	8.99	2178.39 e 3 v 3 f	9.06
0709.40 e 3 v 2½ f	9.08	1521.37 e 2 v 3 f	9.01	1860.39 e 3 v	9.04	2180.38 v = e	8.81
0709.44 e 3 v 3 f	9.05	1522.34 d 4 v 1 e	8.74	1862.30 e 3 v 4 f	9.02	2182.37 e 3 v 4 f	9.02
0748.39 e 3 v 3 f	9.05	1527.32 d 3½ v 2 e	8.69	1864.39 v 1 e	8.73	2184.42 d 3 v 1 e	8.72
0749.34 d 4 v 4 e	8.64	1532.43 d 3 v 2 e	8.67	1865.31 v = e	8.81	2186.36 e 4 v 4 f	9.06
0750.40 e 2½ v 4½ f	8.99	1540.29 e 3 v 2½ f	9.08	1867.42 e 2 v 5 f	8.95	2187.35 e 3 v 5 f	8.96
0751.41 e 3 v 3 f	9.06	1549.33 v 1 e	8.73	1870.34 e 4 v 3 f	9.09	2192.37 e 3 v 5 f	8.99
0752.30 e 3 v 2½ f	9.08	1558.33 v 1 e	8.73	1873.29 d 1 v 2 e	8.58	2193.34 e 1 v	8.89
0753.39 e 2 v 4 f	8.97	1565.37 e 4 v 4 f	9.06	1874.43 d 3 v 1 e	8.72	2198.40 e 3 v 7 f	8.96
0758.47 e 3 v 4 f	9.02	1566.37 v 1 e	8.73	1875.29 e 3 v 6 f	8.97	2210.40 e 2 v 3 f	9.01
0758.54 d 3 v 2 e	8.67	1568.32 e 2½ v 4 f	9.00	1880.29 e 1½ v	8.92	2211.33 e 5 v 2½ f	9.14
0760.34 e 2 v 5 f	8.95	1576.28 d 3 v 2 e	8.67	1901.18 e 3 v 3 f	9.05	2212.32 e 2 v 5 f	8.95
0761.32 e 3 v 4½ f	9.01	1727.50 d 3 v 1½ e	8.70	1906.36 e 2 v 5 f	8.95	2212.46 e 3 v 2 f	9.10
0770.37 e 3 v 5 f	8.99	1730.46 e 2 v 3½ f	8.99	1907.38 d 2 v 2 e	8.64	2213.31 d 1 v 2 e	8.58
0775.42 e 4 v 3½ f	9.07	1732.48 v 1 e	8.73	1913.37 v = e	8.81	2214.33 e = v	8.81
0777.39 e 1 v 5 f	8.89	1734.44 e 1½ v 3 f	8.97	1920.32 e 3 v 3 f	9.05	2218.38 v 1½ e	8.70
0782.38 f 2 v 3 g	9.40	1741.45 d 4 v 2 e	8.70	1925.34 e 2½ v 7 f	8.94	2219.33 d 3 v 2 e	8.67
0785.30 e 2 v 4 f	8.97	1743.47 e 2 v 5 f	8.95	1928.32 e 1 v	8.89	2223.45 d 2 v 1 e	8.70
0788.37 d 4 v 3 e	8.66	1744.45 e 1½ v 4 f	8.94	1935.28 v = e	8.81	2230.28 v = e	8.81
0788.41 d 3 v 3 e	8.64	1745.46 v 2 f	9.15	1944.31 e 3 v 3 f	9.06	2231.36 e 2 v 4 f	8.97
0789.40 e 3 v 5 f	8.99	1760.43 e 1 v	8.89	1951.34 d 2 v 2 e	8.64	2231.40 e 3½ v 3 f	9.08
0791.29 e 3½ v 2 f	9.12	1761.45 d 2 v 2 e	8.64	1964.23 e 2 v	8.96	2232.26 e 1 v	8.89
0800.38 e 4 v 2 f	9.14	1767.49 v = e	8.81	1970.25 d 3 v 2 e	8.67	2232.36 e 3 v 5 f	8.99
0801.34 f 1 v 3 g	9.36	1768.43 e 2 v 4 f	8.97	2096.48 d 3 v 1 e	8.72	2234.42 e 1 v	8.89
0804.38 e 1 v	8.89	1770.49 v = d	8.47	2098.47 e 1 v	8.89	2242.26 v = e	8.81
0807.31 d 2 v	8.62	1777.47 d 3 v 1 e	8.73	2099.49 e 4 v 2 f	9.14	2244.46 e 2 v 4 f	8.97
0807.38 v = e	8.81	1778.49 v = e	8.81	2100.47 e 2 v 4 f	8.97	2245.26 e 4 v 3 f	9.09
0887.24 e 2 v 3 f	9.01	1781.41 d 3 v 2 e	8.67	2101.45 d 2½ v 1½ e	8.68	2247.26 d 3 v 2 e	8.67
0892.24 e 3 v 5 f	8.99	1783.44 e 1½ v 5 f	8.92	2102.46 v = e	8.81	2249.26 e 3 v 4 f	9.02
0899.26 e 4 v 1 f	9.20	1784.41 e 4 v 2 f	9.14	2107.46 e 1½ v 5 f	8.92	2250.25 e 2½ v 5 f	8.97
0901.25 e = v	8.81	1787.42 e 1 v	8.89	2115.45 e 1 v 5 f	8.89	2251.25 e 4 v 3 f	9.09
0903.26 e 4 v 2 f	9.14	1793.47 e 3 v 3 f	9.06	2117.45 d 3 v 4 f	8.83	2253.25 v ½ e	8.77
1036.42 d 4 v 1½ e	8.72	1796.45 e 1½ v 4½ f	8.93	2118.45 e 2 v 5 f	8.95	2254.25 e 4 v 3 f	9.09
1074.38 e 2 v 4 f	8.97	1812.38 e 2 v 5 f	8.95	2119.46 e 1 v	8.89	2258.25 e 1 v	8.89
1074.45 e 3 v 3 f	9.05	1820.41 d 3 v 1 e	8.73	2120.41 d 3 v 1 e	8.72	2258.40 e 1 v	8.89

Summary of Results

In 1914 the writer was arranging the construction of a polarising photometer for the observation of variable stars. The appearance of the artificial star, whose light has passed through apertures much smaller than the object glass of the telescope through which the variable star is seen, is however so different from the latter that it was intended to use a neutral tinted wedge placed before the eyepiece for the simultaneous

extinction of both images. Meantime observations were commenced by the Herschel-Argelander method, and these were continued when the construction of the photometer became impossible.

The accuracy of observations of variable stars depends upon the presence of suitable comparison stars within a convenient distance. A photometer enables the observer to use stars at a greater distance than it is advisable to do without that instrument, but except on the more or less rare occasions when the sky is perfectly clear, photometers scarcely repay the additional work they cause. On the whole photometers are more suitable for observing eclipsing binaries than for long period variable stars. The writer's observations, made single handed, take at present four minutes each including setting the instrument and turning the roof. In the beginning they took longer, till he became acquainted with the constellations.

In 1872 (*A. N.* 1897) Julius Schmidt in Athens pointed out that the intensity of the red colour of variable stars increases with the period. The comparison of the brightness of a red with a bluish white star is somewhat difficult but difference of spectral class causes still greater difficulty, as a sharp point has then to be compared with a coloured disc (the chromatic aberration of the object glass being corrected for double stars). It is well to use as low a magnifying power as possible, and to finish the observation quickly. A large astro-photographic, short focus lens, corrected for the red instead of the blue, used in conjunction with a Kellner eyepiece with a very large field lens, would be in ideal telescope for such work.

The value of the step (the average is 0.091 mag.) depends upon several circumstances. It increases (together with the probable error) during haze or fog, cirro-stratus, strong moonlight, and when the difference in magnitude between the comparison stars is greater than usual, or when the stars are faint. The accuracy of observations of variable stars does not depend upon the probable errors determined from single nights' observations. These are of minor importance. In view of the small irregularities in the variation of the stars (excepting the eclipsing binaries) the single observations are as accurate as they need be, and the accuracy can be indefinitely increased by repeating the observations on different nights. The value of an observation depends upon the avoidance of constant (systematic) errors, and for this reason the observer should be kept in ignorance of the nature of the variation of each individual star. The writer has been so careful to avoid bias that he has occasionally missed observing at important epochs, and has occasionally compared stars that he did not wish to include.

The hour-angle error, which is considerable, was eliminated by looking at each star in succession after placing it in the same position in the field of view. In case of naked eye observations the error is avoided by looking straight at the stars, and then turning round and looking at them leaning backwards, and taking the mean of both observations (comp. "Observations on the zodiacal light," *A. N.* 3579). The systematic errors in double star observations begin when a pair is so close that the components can be bisected simultaneously, and disappear at greater distances.

In previous papers certain variable stars are mentioned, the minima of which occur nearer the past than the following maximum, the opposite being usually the case. This must not be understood to mean that they belong to two different classes. When M signifies the date of maximum, m the date of minimum, P the period, and $p = (M - m)\colon P$, then the most probable value of p is 0.455, and for 50 per cent of the number of variable stars, whose periods exceed 50 days, p lies between 0.42 and 0.48. For this reason values of p above 0.50 are scarce. The approximate percentage of stars with p between 0.19 and 0.32 is : 3, between 0.32 and 0.35 : 3, for p equal to 0.35 or 0.36 : 4, 0.37 or 0.38 : 4, 0.39 or 0.40 : 6, 0.41 : 5, 0.42 : 7, 0.43 : 6, 0.44 : 5, 0.45 : 11, 0.46 : 9, 0.47 : 8, 0.48 : 5, 0.49 : 8, 0.50 : 3, 0.51 : 0, 0.52 : 3, 0.53 : 3, 0.54 : 6, between 0.55 and 0.57 : 3, between 0.58 and 0.67 : 5. This distribution shows that the deviations are distributed according to the law of accidental errors.

With regard to the stars whose periods are less than 50 days, p increases with the period. When the period is half a day (the number of stars included was 14) p is 0.21, and when the period is 15 days p is 0.37 (the number of stars included with periods between 9 and 17 days was 27). The periods mentioned are those that most frequently occur. The light curves of flash stars are wavy like the curves corresponding to long period stars, but the waves, more or less, disappear when the means of many periods are taken.

It would be interesting to have the mean magnitudes of variable stars, determined from say the mean of 12 equidistant ordinates of the light curve, during as many periods as possible in order to ascertain the nature of the variation of the mean magnitude.

It has been suggested that the value of the period should be determined by comparison of the epochs when the variable star passes through the magnitude, at which the rate of variation is greatest, but this method

is feasible only in the case of the eclipsing binaries. In the case of ordinary variable stars the shape of the light curve changes too much. Some stars, formerly well known periodic variables, have lost their periodicity and in some cases show no longer any variation. When it happens that such a star begins to vary again, the occurrence of the maxima agrees, more or less, with the old formula. Variability at one time or another is probably the rule rather than the exception among the fixed stars. The *Sun* having varied in magnitude at some time would account for the ice age on the *Earth* at least as well as any other cause as yet suggested.

Kowloon, Elgin Rd., Sutton, Surrey,
2nd March, 1920.

OBSERVATIONS OF DOUBLE STARS,

MADE AT THE EMERSON MCMILLIN OBSERVATORY,

By H. C. LORD, *Director.*

The following observations of double stars were made by the writer during the summer and fall of 1919 with the 12″½ equatorial of the Emerson McMillin Observatory and include stars whose orbits have been computed as well as those classed as binary or probably binary in BURNHAM's "*General Catalogue.*" The numbers of the stars refer to this catalogue.

The value of one revolution of the micrometer adopted was the mean of four determinations made from observations of POLARIS by the writer in 1896 and of three determinations made by PROFESSOR MANSON in 1908, 1909, and 1910. The separate means of each observer being in substantial agreement.

The program of observing finally adopted was to make four settings for position angle, reversing the micrometer 180° between each setting. These were then followed by three measures of the double distance. The zero of the position circle was determined on twenty-four nights but the results were so accordant that the mean was used in the reductions. This program was generally but not strictly adhered to. No attempt was made to estimate the magnitudes. The powers used were either 270 or 340.

B. G. C. 426 Σ 60	°	″
1919.862	257.3	7.00
1919.867	258.4	7.30
1919.870	258.5	7.38
1919.87	258.1	7.23

B. G. C. 482 Σ 73		
1919.862	52.2	0.96
1919.867	52.4	1.01
1919.873	52.3	1.00
1919.87	52.3	0.99

B. G. C. 4122 Σ 1110		
1919.095	215.9	5.02
1919.101	216.4	5.03
1919.136	219.2	5.10
1919.334	219.7	4.89
1919.342	219.5	5.25
1919.20	218.1	5.06

B. G. C. 5030 Σ 1338		
1919.334	180.9	1.68
1919.377	182.8	1.54
1919.394	182.6	1.84
1919.402	181.4	1.48
1919.38	181.9	1.64

B. G. C. 5734 Σ 1523	°	″
1919.342	105.6	3.68
1919.399	103.8	3.15
1919.402	102.7	3.26
1919.435	106.8	2.87
1919.39	104.7	3.24

B. G. C. 6102 Σ 1622		
1919.435	258.8	11.62
1919.446	259.3	11.44
1919.44	259.0	11.53

B. G. C. 6668 Σ 1788		
1919.459	83.6	2.82
1919.465	83.4	2.93
1919.484	81.4	3.06
1919.47	82.8	2.94

B. G. C. 7034 Σ 1888		
1919.503	111.3	2.36
1919.533	111.6	2.41
1919.552	110.4	2.45
1919.53	111.1	2.41

B. G. C. 7117 β 119	°	″
1919.492	298.7	1.86
1919.495	297.2	1.71
1919.498	297.2	1.77
1919.50	297.7	1.78

B. G. C. 7273 Σ 1944		
1919.503	329.3	1.30
1919.533	324.6	1.17
1919.552	327.1	1.15
1919.53	327.0	1.21

B. G. C. 7318 Σ 1954		
1919.495	183.2	3.93
1919.492	184.3	3.89
1919.498	182.7	3.88
1919.50	183.4	3.90

B. G. C. 8340 Σ 2272		
1919.566	134.6	5.48
1919.577	136.8	5.47
1919.599	134.7	5.49
1919.58	135.4	5.48

B. G. C. 8663 OΣ 358

	°	″
1919.566	184.8	1.89
1819.574	182.7	1.90
1919.577	184.1	1.90
1919.599	183.1	1.93
1919.58	183.7	1.91

B. G. C. 8798 Σ 2398

1919.709	152.8	17.63
1919.728	154.7	17.52
1919.733	153.4	17.40
1919.72	153.6	17.52

B. G. C. 9602 Σ 2576

	°	″
1919.709	279.7	2.04
1919.728	277.2	1.92
1919.733	277.8	1.72
1919.72	278.2	1.89

B. G. C. 10685 Σ 2744

1919.728	154.8	1.68
1919.736	155.3	1.62
1919.739	155.6	1 55
1919.73	155.2	1.62

B. G. C. 11743 Σ 2909

	°	″
1919.796	306.4	3.04
1919.807	306.5	2.86
1919.813	306.3	3.02
1919.81	306.4	2.97

The Emerson McMillin Observatory,
February 14th, 1920.

OBSERVATIONS OF COMET *FINLAY*,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral J. A. Hoogewerff, U. S. Navy, Superintendent.]

W. M. T.	☄'s apparent place		☄ − ★		Comp.	log pρ		Ap. pl. red of ★		Seeing	★
1919 h m s	h m s	° ′ ″	m s	′ ″				s	″		
Nov. 13 7 46 51	23 4 9.19	− 8 11 29.5	+1 6.18	−4 2.7	*t* 25 , 5	8.347	0.807	+3.99	+25.8	*p*	1
17 7 37 8	23 37 3.93	− 3 19 31.2	−0 4.26	−1 29.3	*d* 10 , 8	8.501*n*	0.770	+4.09	+26.9	*f*	2
22 7 51 11	0 14 24.30	+ 2 15 49.3	+2 37.61	+0 13.0	*t* 35 , 7	8.589*n*	0.718	+4.24	+27.5	*p*	3
24 7 47 23	0 27 56.12	+ 4 15 19.6	+1 15.69	+1 1.3	*t* 40 , 8	8.761*n*	0.697	+4.32	+27.3	*f*	4
Dec. 15 8 7 54	2 10 9.55	+17 14 23.0	−0 11.13	−0 49.7	*d* 10 , 8	8.759*n*	0.510	+5.04	+23.1	*p*	5
20 8 12 49	2 26 52.16	+18 50 57.5	−0 24.56	−5 24.2	*d* 10 , 8	8.618*n*	0.477	+5.17	+21.7	*f*	6
22 8 3 34	2 33 1.91	+19 23 57.4	+0 18.85	+1 17.2	*d* 10 , 8	8.759*n*	0.466	+5.21	+21.2	*p*	7

Nov. 13. Brightness 9^m. Diffuse. Transits very poor. Nov. 17. Haze. Nov. 22. Poor observation. Nov. 24. Transits poor. Haze. Dec. 15. Clouds, Dec. 20. Comet faint. Used a step star. Haze. Dec. 22. Comet faint, diffuse. Haze. Poor observation.

Comp.: *d* = direct measures, clock running; *t* = transits.

Mean Places of Comparison Stars for 1919.0

★	α	δ	Authority	★	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	23 2 59.02	− 8 7 52.6	*A.G. Wien-Ottak.* 8217	6	2 27 11.55	+18 56 0.0	*A.G. Berlin A* 692
2	23 37 4.10	− 3 18 28.8	*A.G. Straszburg* 8117				(12^m, comp. with 8, 1919 Dec. 22
3	0 11 42.45	+ 2 15 8.8	*A.G. Albany* 35	7	2 32 37.85	+19 22 19.0	$\Delta\alpha = -1^m 26^s.27$, $\Delta\delta = -21''.6$, 1919.0)
4	0 26 36.11	+ 4 13 51.0	*Cin. Pub.* No. 18:4, 57				
5	2 10 15.64	+17 14 49.6	*A.G. Berlin A* 625	8	2 34 4.12	+19 22 40.6	*A.G. Berlin A* 715

U. S. Naval Observatory, Washington, D. C., 1920 Mar. 22.

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DIRECT MICROMETRICAL OBSERVATIONS OF THE *SUN*, HELIOGRAPHIC POSITIONS OF SUNSPOTS.*

By E. D. Roe, Jr.

§1. Introduction

In No. 744 of the *Journal*, I described a method and appliances for observing the *Sun* directly with the micrometer. The object of the present paper is to exhibit the mathematical treatment used by me in determining the heliographic positions of sun spots. The method in short is this. The fixed thread of the micrometer, placed at the center of the tube, is set parallel to the *Sun's* axis at the time of observation, and is then brought to bisection of the point whose position is to be observed. The movable thread is then run out until it is tangent to the *Sun's* limb. The distance from the axis is obtained by subtracting the reading from the semi-diameter of the *Sun* at the same time. This gives a coördinate x positive if east, negative if west. The fixed thread is then turned through 90° and a coördinate y positive if north, and negative if south, obtained in the same manner. All observations are made with the driving clock on. One turn of the screw is the unit of linear measure used.

It is evident that the measurements in the plane of the micrometer are inclined at an angle to the diametral plane through the *Sun* perpendicular to the line from the observer to the center of the *Sun*, also that we have a conical projection. Two transformations of x and y are therefore necessary, the first to refer all the observations to the diametral plane perpendicular to the line to the *Sun's* center, and a second transformation from conical to orthogonal projection. When the coördinates of the orthogonal projection x_0, y_0 have been obtained, two parts of a spherical triangle on the surface of the *Sun* are immediately determined by solid analytic geometry, and a third part, the latitude of the center of the *Sun's* disc, from the nautical almanac. The vertices of the spherical triangle are the point in the spot, a pole of the *Sun*, and a point beyond the pole on the circle through center and pole at a distance from the pole equal to the latitude of the center of the *Sun's* disc. The case in triangles to be solved is that of two sides and the included angle given. Two of the required parts yield the latitude and longitude from the center, midway between the poles, from which the absolute longitude results by addition or subtraction of the longtiude of this center obtained from the nautical almanac. So far as I know this method has not been used before.

It should be added that the motive for the work was twofold. 1. To make the telescope farther available for daylight work. 2. To encourage work by amateurs with a small telescope. As remarked in my previous paper, the method of direct observation can be used with any telescope driven by clock work, but for this work on the *Sun*, by this method, the small telescope will have the advantage, unless an eye piece for the large instrument can be made with a field of at least 21′ of arc. This for the 40-inch refractor of the Yerkes Observatory would require an eye piece with a field lens of 4.6 inch aperture. Most beautiful views can be obtained with the large telescope, though perhaps not under all conditions of atmosphere. On August 21, 1919, I diaphragmed the 20-inch refractor of the Chamberlin Observatory, which I was permitted to use through the courtesy of Dean Howe, to 3¾ inch. The delicacy and exquisiteness of detail in feathery and filamentary structure and burred appearance of nuclei, and brilliance of bridges of flame, on the great spots of the group then on, exceeded anything ever seen before, an opinion in which Director Howe concurred. No photograph could begin to compare with it. At the time the heavens were smoky from forest fires which may have made the seeing unusually good. The distances subtended perpendicularly to the line of sight by the spots were easily measured and evaluated.

*Presented at the Meeting of the American Astronomical Society, 2 September, 1919.

§2. The Transformation from Conical to Orthogonal Projection

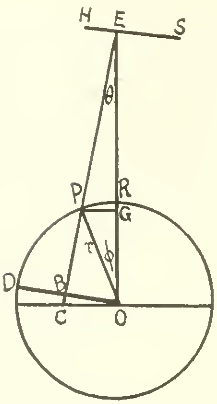

Fig. 1

In Fig. 1 let P represent a spot on the surface of the *Sun*. It is seen at C on the diametral plane perpendicular to EO, a line from the point of observation to the center of the *Sun*. DB is parallel to HS representing the plane of the micrometer and the focal image of the *Sun* in that plane. EH on the focal image represents the distance BD in a parallel plane from the spot to the limb of the *Sun*. HE is perpendicular to EP which coincides with the axis of the tube of the telescope. $OB = OD - BD = s$, is the distance from O of the spot's projection on OD. $s = (x^2 + y^2)^{\frac{1}{2}}$, where x and y are obtained from measures on the focal image in the plane HS in the manner already described. $EO = d$, the distance of the *Sun* from the point of observation. $OD = r$, the semidiameter of the *Sun* from E. $COB = OEB = \theta$. Sin $\theta = \frac{s}{d}$. From the figure $PE \sin\theta = r \sin\varphi$, where $\varphi = GOP$. $PE = BE - BP = (d^2 - x^2 - y^2)^{\frac{1}{2}} - (r^2 - x^2 - y^2)^{\frac{1}{2}}$.

Thus

$$r \sin\varphi = \frac{(x^2 + y^2)^{\frac{1}{2}}}{d}\left((d^2 - x^2 - y^2)^{\frac{1}{2}} - (r^2 - x^2 - y^2)^{\frac{1}{2}}\right).$$

Next pass planes through E embracing x, y, and s. Spherical figures will be formed on the *Sun's* surface as indicated in Fig. 2. RD is perpendicular to HD, $HJ = 90°$, DBJ is a right spherical and RBJ a quadrantal triangle. $a = \theta$. From DBJ we have $\cos c = \cos a \cos b$,

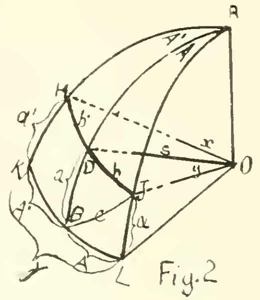

Fig. 2

$$\cos B = \frac{\tan a}{\tan c} = \frac{\sin a \cos b}{(1 - \cos^2 a \cos^2 b)^{\frac{1}{2}}}.$$

From the quadrantal triangle RBJ

$$\tan c = \frac{\tan A}{\sin B},$$

whence

$$\tan A = \tan b \sec a = \frac{x}{y}\sec\theta = \frac{xd}{y\,(d^2 - x^2 - y^2)^{\frac{1}{2}}}.$$

$$\text{Similarly } \tan A' = \frac{yd}{x\,(d^2 - x^2 - y^2)^{\frac{1}{2}}}.$$

$$\text{Also } \sin\alpha = \cos B \sin c = \sin\theta \cos b = \frac{y}{d},$$

$$\sin\alpha' = \frac{x}{d},$$

$$\cos\alpha = \frac{(d^2 - y^2)^{\frac{1}{2}}}{d}, \qquad \tan\alpha = \frac{y}{(d^2 - y^2)^{\frac{1}{2}}},$$

$$\cos\alpha' = \frac{(d^2 - x^2)^{\frac{1}{2}}}{d}, \qquad \tan\alpha' = \frac{x}{(d^2 - x^2)^{\frac{1}{2}}}.$$

$$\sin A = \frac{xd}{[(d^2 - y^2)(x^2 + y^2)]^{\frac{1}{2}}},$$

$$\cos A = \frac{y(d^2 - x^2 - y^2)^{\frac{1}{2}}}{[(d^2 - y^2)(x^2 + y^2)]^{\frac{1}{2}}},$$

$$\sin A' = \frac{yd}{[(d^2 - x^2)(x^2 + y^2)]^{\frac{1}{2}}},$$

$$\cos A' = \frac{x(d^2 - x^2 - y^2)^{\frac{1}{2}}}{[(d^2 - x^2)(x^2 + y^2)]^{\frac{1}{2}}}.$$

$\gamma = A + A'$, $\cos\gamma = -\tan\alpha\tan\alpha' =$

$$-\frac{xy}{[(d^2 - x^2)\,(d^2 - y^2)]^{\frac{1}{2}}}$$

$$\sin\gamma = \frac{d(d^2 - x^2 - y^2)^{\frac{1}{2}}}{[(d^2 - x^2)\,(d^2 - y^2)]^{\frac{1}{2}}}$$

To find the coördinates of the point P on the *Sun* referred to the diametral plane perpendicular to OE, we note that the angle between the projected coördinates is $A + A'$, that y_0 makes the angle A with $r\sin\varphi$, and x_0 the angle A' with it. Hence x_0, y_0 are found from

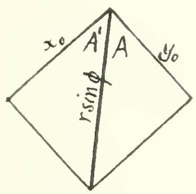

Fig. 3

$$\frac{x_0}{\sin A} = \frac{y_0}{\sin A'} = \frac{r\sin\varphi}{\sin(A + A')},$$

whence by using the values of $\sin A$, $\sin A'$, $\sin(A + A')$, $r\sin\varphi$ and reducing, we obtain,

$$x_0 = \frac{x(d^2 - x^2)^{\frac{1}{2}}}{d}\left(1 - \left[\frac{r^2 - x^2 - y^2}{d^2 - x^2 - y^2}\right]^{\frac{1}{2}}\right),$$

$$y_0 = \frac{y(d^2 - y^2)^{\frac{1}{2}}}{d}\left(1 - \left[\frac{r^2 - x^2 - y^2}{d^2 - x^2 - y^2}\right]^{\frac{1}{2}}\right).$$

These are the exact formulas for transforming from conical to orthogonal projection. They may also be obtained by a transformation from rectangular coördinates x, y, z, in which the z axis parallel to the line PE, passes through O, to the coördinates x_0, y_0, z_0, in which the axis of z_0 coincides with OE. but as a proportionality factor and several direction cosines have to be ascertained before the transformation is complete, the method used seems to be by all means the simpler.

If $x = y = 0$, $x_0 = y_0 = 0$. If $x = r$, $y = 0$,

$$x_0 = \frac{r(d^2 - r^2)^{\frac{1}{2}}}{d}.$$

As the function $\frac{u(d^2 - u^2)^{\frac{1}{2}}}{d}$ taken from $u = 0$ to $u = r$ differs from u at most by less than half a unit in the third decimal place and since our data are only given to three places of decimals, we may take for purposes of computation

$$x_0 = x\left(1 - \left[\frac{r^2 - x^2 - y^2}{d^2 - x^2 - y^2}\right]^{\frac{1}{2}}\right),$$

$$y_0 = y\left(1 - \left[\frac{r^2 - x^2 - y^2}{d^2 - x^2 - y^2}\right]^{\frac{1}{2}}\right).$$

And computations farther show that

$$x_0 = x\left(1 - \left[\frac{r^2 - x^2 - y^2}{d^2}\right]^{\frac{1}{2}}\right)$$

$$= x\left(1 - \frac{r}{d}\left[1 - \frac{x^2 + y^2}{r^2}\right]^{\frac{1}{2}}\right)$$

$$= x(1 - \sin \textcircled{H} \sin\Phi),$$

$$y_0 = y(1 - \sin \textcircled{H} \sin\Phi),$$

will give results correct to three places of decimals. $\textcircled{H}$ is the angular semi-diameter of the *Sun's* disc from E at the time of the observation, but the geocentric may be used.

$$\Phi = \cos^{-1}\frac{s}{r}.$$

For r may be taken the geocentric semi-diameter of the *Sun's* disc expressed in turns of the micrometer screw.

§3. The Angle Between the Co-ordinates of Orthogonal Projection

As the angle between x and y is taken as $90°$, as shown by the arc HJ in Fig. 2 and as RK and RL are each $90°$, it is evident that the angle $A + A' = \gamma$ between x_0 and y_0 is greater than $90°$. The following investigation shows by what limit it exceeds $90°$.

We have

$$\cos\gamma = -\frac{xy}{[(d^2 - x^2)\,(d^2 - y^2)]^{\frac{1}{2}}}$$

and we wish to find the maximum value of $-\cos\gamma$.

For this,

$$\frac{x^2\, y^2}{(d^2 - x^2)\,(d^2 - y^2)}$$

will be at a maximum and

$$u = \frac{(d^2 - x^2)\,(d^2 - y^2)}{x^2\, y^2} = \frac{d^4}{x^2\, y^2} - \left(\frac{1}{x^2} + \frac{1}{y^2}\right) d^2 + 1$$

will be at a minimum. $x^2 + y^2 = s^2$. For a given value of s

$$2x\, d\, x + 2y\, d\, y = 0,\ \frac{dy}{dx} = -\frac{x}{y},$$

$$\frac{du}{dx} = D_x u + D_y u\, \frac{dy}{dx}$$

$$= \frac{2d^2}{x^3}\left(1 - \frac{d^2}{y^2}\right) - \frac{2d^2}{y^3}\left(1 - \frac{d^2}{x^2}\right)\frac{x}{y} = 0$$

gives

$$(x^2 - y^2)\,(d^2 - x^2 - y^2) = 0.$$

whence

$$x^2 = y^2, \quad \text{or} \quad d^2 = x^2 + y^2.$$

$x = y$ corresponds to the maximum value of $-\cos\gamma$, since $d^2 = x^2 + y^2$ and $x = -y$ are not admissible for consideration within the limited range of the function employed in the practical problem.

Thus

$$\cos\gamma = -\frac{x^2}{d^2 - x^2}$$

gives the greatest divergence of γ from 90° for a given s, and this increases in value with x^2. The greatest value of s allowed is $s = r$.

Thus

$$2x^2 = r^2,\ x^2 = \frac{r^2}{2}$$

gives the greatest value of x^2, whence

$$-\cos\gamma = \frac{r^2}{2d^2 - r^2} = \frac{\sin^2 \mathrm{II}}{1 + \cos^2 \mathrm{II}},$$

which becomes larger with II.

The largest value that II can have is less than 16′ 18″. For this value of II

$$\gamma = 90^\circ\ 00'\ \ 2''.31,$$

and thus the greatest possible theoretical divergence* from 90° of the angle between the coördinates of orthogonal projection is less than 2″.31. This angle is clearly below any possible observation with the position micrometer, since the finest position circles are only capable of distinguishing 1/100 of a degree or 36″ in the position angle. We proceed in the next step as if the angle between the axes is 90°.

§4. The Application of Analytic Geometry

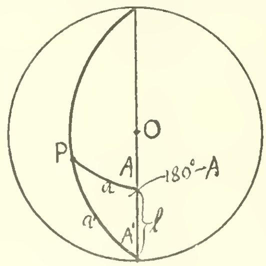

Fig. 4

By solid analytic geometry, if x_0 and y_0 are rectangular coördinates of P, a point in a sun spot on the surface of the *Sun*, with origin at the *Sun's* center O, and l is the latitude of the center of the *Sun's* disc,

we have

$$-x_0 = r \sin a' \sin A',\quad y_0 = r \cos a',$$

whence

$$\cos a' = \frac{y_0}{r},\ \sin A' = \frac{-x_0}{(r^2 - y_0^2)^{\frac{1}{2}}}.$$

We now have a', A', and l, from which we find a, 180° − A. 90° − a is the latitude and A is the longitude from a meridian through O and E, Fig. 1, and the *Sun's* axis at the time of observation, from which the longitude from the prime meridian can be obtained by algebraic addition.

*The angle γ diverges most on any day when the spot is exactly on the limb; practically it is not likely to be observed in this position.

§5. Formulas for the Solution

Any of the formulas for the case, given two sides and the included angle may be used. Among others these may be employed.

ctn Long.

$$= \frac{(r^2 - x_0^2)^{\frac{1}{2}}}{x_0} \sin \left(I - \tan^{-1} \left(\frac{(r^2 - x_0^2 - y_0^2)}{y_0} \right) \right).$$

sin Lat.

$$= \frac{\cos I \cos \left[\cos^{-1} \frac{y_0}{r} - \tan^{-1} \left[\frac{r^2 - x_0^2 - y_0^2}{r^2 - y_0^2} \right]^{\frac{1}{2}} \tan I \Big) \right]}{\cos \tan^{-1} \left(\left[\frac{r^2 - x_0^2 - y_0^2}{r^2 - y_0^2} \right]^{\frac{1}{2}} \tan I \right)}.$$

As a check we may use $\sin a \sin A = \sin a' \sin A'$, or $\sin a' \sin A' = \sin$ Long. cos Lat., or sin Long. cos Lat. $\frac{r}{x_0} = 1$. The regular formulas for this case consisting of Napier's Analogies may be used and the theorem of sines applied as a check, after all the parts are found. It is not necessary to calculate exact values of d, r, and sin $\textcircled{\scriptsize II}$ for the point E, since the geocentric values given by the nautical almanac may be used without appreciable error. Thus to get log sin $\textcircled{\scriptsize II}$ subtract the logarithm given for the distance of the *Sun* from 7.6676771 10. Thus for 22 June, 1919 Greenwich Mean Noon this logarithm is 0.0070525, hence at this time log sin $\textcircled{\scriptsize II}$ = 7.6606246 10.* In a subsequent paper the reduction by the foregoing method of many observations made at Roe Observatory will be presented with farther notes or remarks.

§6. Discussion of the Fundamental Assumptions

In Fig. 5, $D'F'$ represents the focal image of the *Sun*. OD is parallel to $D'F'$. EP the axis of the tube is perpendicular to $D'F'$ and to OD. ET is tangent to the *Sun* at T. OT is perpendicular to ET. P represents a sun spot. OB is its distance from the center on OD. $D' = T'$, $P' = B' = E$, O', F' are the corresponding points to D and T, B and P, O and F respectively. We shall use OB as representing an x coördinate. EB is perpendicular to OD. $OED = \textcircled{\scriptsize II}$, $BEO = \theta$. $OT = r$, $EO = d$.

*This value of log sin $\textcircled{\scriptsize II}$ is obtained from sin $\textcircled{\scriptsize II} = \frac{r}{d}$ where r and d are expressed in miles, and d is the variable geocentric distance. The exact value of $\textcircled{\scriptsize II}$ so obtained is about 1″.86 smaller than that given in the American Ephemeris Tables, but is the value used in the Ephemeris for the calculation of eclipses.

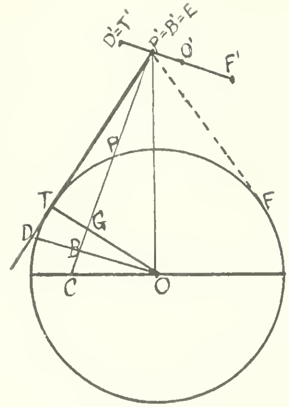

Fig. 5

Most persons would probably be disposed to admit the assumptions used in this paper as being reasonable and without requiring their further justification. The object of the present section is to furnish their rigorous justification. These fundamental assumptions are that, without measurable error within the limits in which observations are proposed to be made, the micrometer measures may be indifferently regarded, as usual, (1) as angular measures, or, (2) as linear measures; (3) that such linear measures are made on the focal image of the *Sun*, and that the measure is also the length of the corresponding segment in the *Sun* on a line from the center of the *Sun* parallel to the plane of the micrometer and between the corresponding points; (4) that the length OD, Fig. 5, may be replaced by the length OT; and (5) that in the case of measuring x and y the angle is not changed by swinging the plane of such measurement out from the center of the tube.

(1), (2), (3), (4). In order to obtain OB we assume we may subsract BD from OT, the radius r, when rigorously it should be subtracted from $OD = r \sec (\textcircled{\scriptsize II} - \theta)$. As $OD > OT$, the amount of error involved in this is $OD - OT = r(\sec (\textcircled{\scriptsize II} - \theta) - 1)$, greatest when $\theta = 0$, and when $\textcircled{\scriptsize II}$ is greatest. For my micrometer, one turn of the screw taken as 20″.09 for this work, and for $\textcircled{\scriptsize II}$ = 16′ 18″, r = 48.681, (see the assumption following) and $r \sec \textcircled{\scriptsize II}$ = 48.6815. Thus the error amounts to less than 0.0005, and is usually much less because θ will not generally be zero, nor $\textcircled{\scriptsize II}$ quite so large. For a micrometer with 10″ to a turn of the screw the error would be less than

0.001*, but even if it were one unit in the third place, it is less than the probable error of setting, and hence may be disregarded. Thus we are justified in using $OT - BD$ instead of $OD - BD$ for OB. We shall take the number of turns of the screw in the angle $\textcircled{H}$ as the number of units in the radius r of the *Sun*. As we may take the measure of one such distance at pleasure, this needs no further justification. Thus if $\textcircled{H} = cr$, where $\textcircled{H}$ is expressed in radians and

$$c = \frac{u\pi}{180 \times 60 \times 60},$$

u is the number of seconds to one turn of the screw, we shall take r as the measure of the radius r, and we shall be able to determine the error of assuming OB to be expressed by x, the number of turns of the screw in the angle θ, by comparing x with the true value of OB as obtained from the angle θ and the distance d in the right triangle OBE.

We have

$$r = d \sin \textcircled{H},\ OB = d \sin \theta = \frac{r \sin \theta}{\sin \textcircled{H}},$$

$$\frac{\sin \theta}{\theta} = 1 - \frac{\theta^2}{6} = k,$$

if powers of θ higher than the second are dropped. $\theta = cx$, $\textcircled{H} = cr$, $\sin \theta = \theta k = cxk$, $\sin \textcircled{H} = \textcircled{H}\, k_0 = crk_0$, whence $OB = x \dfrac{k}{k_0}$, with $k \geqq k_0$, as $\theta \leqq \textcircled{H}$. $k = 0$, when $\theta = 0$. The error $v = x\dfrac{k}{k_0} - x$, and is greatest when

$$\frac{dv}{dx} = \frac{1 - \dfrac{3c^2 x^2}{6}}{1 - \dfrac{c^2 r^2}{6}} - 1 = 0,$$

which gives

$$x^2 = \frac{1}{3} r^2, \qquad x = \frac{r}{\sqrt{3}},$$

and this makes the second derivative negative. Hence the error is a maximum when

$$\sin \theta = \frac{x}{d} = \frac{1}{\sqrt{3}} \frac{r}{d}.$$

*In general the number of units of linear measure in the error, for a micrometer with u'' to one turn of the screw, will be $\dfrac{20.09}{u}$ times the error given for my micrometer.

or when $\theta = 9' \, 21''.66$, for which $x = 27.957$, $OB = 27.9570709$ (my micrometer). Thus the greatest possible error inside the limits of observation, in assuming $OB = x$, is less than -0.000071. And it results from our assumption that the numerical measure of the angle is less than the line OB, until $OB = r$, and after that it is greater than OB. Of course when $\theta = 0$, $x = OB = 0$. If we should take OC as x, we would have to compare $OC = d \tan \theta$ with x. Similarly as before

$$\frac{\tan \theta}{\theta} = 1 + \frac{\theta^2}{3} = h, \qquad OC = x\frac{h}{h_0},\dagger \qquad x - x\frac{h}{h_0} = v,$$

is the error. The maximum comes as before for $\theta = 9' \, 21''.66$, $x = 27.957$, $OC = 27.957 \ -0.000142$. Thus the error is considerably greater than before (twice as large and in the opposite sense) which confirms our choice of the previous assumption as the better one. If however we had used the latter assumption we should have obtained

$$x_0 = x\left(\frac{d^2}{d^2 + x^2 + y^2} - \frac{\sqrt{r^2 d^2 - (d^2 - r^2)(x^2 + y^2)}}{d^2 + x^2 + y^2}\right)$$

and by throwing away enough, such as putting

$$\frac{d^2}{d^2 + x^2 + y^2} = 1, \qquad \frac{x^2 + y^2}{d^2} = 0, \qquad \frac{r^2}{d^2} = 0,$$

we get as before,

$$x_0 = (1 - \sin \textcircled{H} \sin \Phi), \text{ etc.}$$

In Fig. 6 P' is the projection of P, O the projection of E. Any plane embracing EP is perpendicular to the plane of x and y because EP is perpendicular to it. x at P' is parallel to x at X and x at P' is perpendicular to EP' and to $P'X$, hence perpendicular to the plane $EP'X$. Therefore x at X is perpendicular to $EP'X$, and hence to EX.‡ This is also seen from work in connection with Fig. 2, where it is shown that $EOX = 90° - \alpha'$. Draw XM perpendicular to OE.

†Naturally we choose here the measure of the angle $\textcircled{H}$ taken from OE to a line from E to the extremity of the radius along OC as the measure of the radius and denote this measure by r and have

$$\tan \textcircled{H} = \frac{r}{d}, \quad \textcircled{H} = rc, \text{ etc.}$$

The difference between the greatest value of $\textcircled{H}$ obtained from $\sin \textcircled{H} = \dfrac{r}{d}$, or $\tan \textcircled{H} = \dfrac{r}{d}$ is less than $0''.0112$ and therefore not certainly measurable.

‡Therefore $XEO = \alpha'$, $\sin \alpha' = \dfrac{x}{d}$, and similarly $\sin \alpha = \dfrac{y}{d}$, and if we had used Fig. 6 along with Fig. 2, we could, without the use of the auxiliary arc c, have obtained from the quadrantal triangle RHJ and from the right triangles RDJ and RDH respectively, $\cos(A + A') = -\tan \alpha \tan \alpha'$, $\tan A = \tan b \sec \theta$, $\tan A' = \tan b' \sec \theta$, etc.

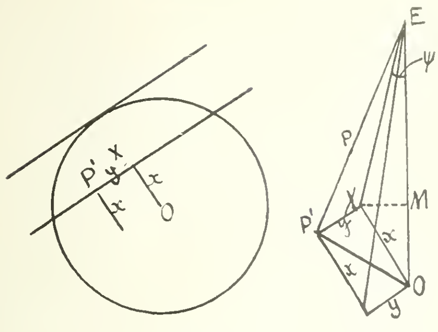

Fig. 6

Then

$$\tan\psi = \frac{MX}{EM} = \frac{x\cos\alpha'}{d - x\sin\alpha'} = \frac{\frac{x}{d}\cos\alpha'}{1 - \frac{x^2}{d^2}}$$

$$= \frac{\sin\alpha'\cos\alpha'}{\cos^2\alpha'} = \tan\alpha'$$

Hence

$$\psi = \alpha', \text{ and } OXE = 90^\circ.$$

If x is taken at the center or at P', the difference between the sines of the two angles is

$$\frac{x}{d} - \frac{x}{(d^2+y^2)^{\frac{1}{2}}} = u,\ x^2 + y^2 = s^2;$$

for a given s; u is a maximum when

$$D_x u = \frac{1}{d} - \frac{1}{(d^2+y^2)^{\frac{1}{2}}} - \frac{x^2}{(d^2+y^2)^{\frac{3}{2}}} = 0,$$

or when

$$x^2 = d^2 + s^2 - d^{\frac{1}{2}}(d^2+s^2)^{\frac{1}{2}}.$$

As u increases with s, the greatest value of u will be for $s = r$, and hence for

$$x^2 = d^2 + r^2 - d^{\frac{1}{2}}(d^2+r^2)^{\frac{1}{2}},$$

or for

$$\frac{x}{d} = \sqrt{1 + \sin^2\textcircled{H} - (1+\sin^2\textcircled{H})^{\frac{1}{2}}} = \frac{\sin\textcircled{H}}{\sqrt{3}},$$

neglecting higher powers of $\textcircled{H}$ than the second, or

$$x = \frac{r}{\sqrt{3}},\quad \theta = 9'\,21''.66$$

as in the previous maximum error.

$$u = \frac{\sqrt{3}}{9}\sin^3\textcircled{H} = 0.00000020511.$$

The decrease in the angle is $0''.0043$ and is without any significance.

One other comparison may be made here. While theoretically the measure will be different according as the fixed thread is placed on the limb or on the spot, the difference will always be, within the limits assigned to our observations, beyond the place of decimals to which we can read the setting. Let s_1 and s_2 be the distances from the center obtained with fixed thread on the spot and limb respectively. From Fig. 5, OB and OG now representing the distances,

$$OB = s_1 = r\sin(\varphi+\theta) = \frac{r\sin\theta}{\sin\textcircled{H}},$$

$$OG = s_2 = \frac{r\sin(\varphi+\theta)}{\cos(\textcircled{H}-\theta)} = \frac{r\sin\theta}{\sin\textcircled{H}\cos(\textcircled{H}-\theta)}.$$

Neglecting higher powers than the second,

$$s_2 - s_1 = \frac{r\theta(\textcircled{H}-\theta)^2}{2\sin\textcircled{H}}.$$

When this is a maximum, $v = \theta(\textcircled{H}-\theta)^2$ must be a maximum, $D_\theta v = (\textcircled{H}-3\theta)(\textcircled{H}-\theta) = 0$, gives $\theta = \textcircled{H}$, which makes the second derivative $D_\theta^2 v = -4\textcircled{H} + 6\theta$ positive, hence gives a minimum, while $\theta = \frac{1}{3}\textcircled{H}$, makes the second derivative negative and gives a maximum. If $\textcircled{H} = 16'\,18''$, $\frac{1}{3}\textcircled{H} = 5'\,26''$, $\textcircled{H} - \theta = 10'\,52''$. $s_1 = 16.22705$, $s_2 = 16.22713$. Hence the maximum difference is not measurable.

No corrections have been made for refraction and parallax. In the case of the former it is believed that with attention to the time of observation, and in the case of the latter from calculations which need not be given here, the errors are not measurable. From what has been done it will undoubtedly appear that in general the mathematical treatment is more refined than the observations possibly can be. The analysis used was adopted as most nearly representing the actual method and interpretation of the observations, while the method of putting the fixed thread on the spot instead of on the limb insures that x and y are measured at 90° from each other and in the same plane. However if a spot is near the middle of the

eastern or western limb and if after turning through 90° its distance from the northern or southern limb is obtained by shifting the center of the tube a little in order to bring the extreme setting of the movable thread into the field of view when the box can be shifted no farther, the measure of y will be in a little different plane from that of x, but the error will not be measurable.

§7. Other Applications of the Method

This method can be applied to the measurement and reduction of photographs of the *Sun* after the usual corrections have been made for photographic errors. The method can also be applied to determine the distance between two points on the *Moon*. The actual distance from the observer to the *Moon* can be found from the geocentric distance, the radius of the point of observation, and the zenith distance of the *Moon*. From the coördinates x, y, of two points on the *Moon*, the positions of X, Y, the axes, at right angles to each other being chosen at convenience, their latitudes and longitudes from the arbitrary reference planes can be found by solving two spherical triangles. From their latitudes and longitudes an additional spherical triangle will be given, whose solution yields as one of its parts the distance between the points, in degrees of arc, from which the distance in miles can be found by using the radius of the *Moon* expressed in miles.

§8. Comparison of Methods

An advantage of this method over the method of transits is that it is easier to set the threads than to observe the time of a single transit accurately. The value of one turn of the screw has been obtained more accurately by a very large number of transits or otherwise than it could be by a single transit. The method of transits gives results comparable to such as would be obtained by micrometer measures if a different value of one turn of the screw were used each time.

The advantage of a photograph for a given time is that it can be remeasured many times, while only one measure can be made for a given time with the micrometer. But if much time is used in photographing from one limb of the *Sun* to the other, as with the spectroheliograph, there would be a different time for each segment of the *Sun*, and the advantage would be with the micrometer.

Roe Observatory,
21 January, 1920.

NOTE ON CERTAIN STARS OF COMPOSITE SPECTRA,

BY ERIC DOOLITTLE.

Lists of stars of this type were published in eight different places by the Harvard College Observatory, to which complete references may be found in their latest paper, Circular No. 221. The inference is that each star having superimposed spectra is either a spectroscopic or a visual binary: many of the stars are known to be double; the remainder are announced as new double stars. Of these the following have recently been discovered visually.

Circular No. 178. *DM* +21°(5156). This is Aitken 2145. 195°.3 0″.15 7.3 7.3 Aitken 3*n*.

No. 184. *DM* −8°(2186). This is Aitken 1580. 132°.8 0″.30 7.4 8.8 Aitken 3*n*.

No. 221. *DM* +34°(2264). Seen double by Argelander and measured by Espin and Franks. An 8.5 magnitude companion is 45″ distant.

DM +38°(4235). This is Aitken 1434. 256°.5 2″.30 6.7 13.7 Aitken 3*n*.

It is improbable, however, that the very faint companion has any influence on the spectrum, so that the star is doubtless a triple system.

DM +53°(3267). This is Aitken 1498. 67°.6 0″.38 8.3 8.6 Aitken 3*n*.

An interesting example in these lists is Burnham's *General Catalogue* No. 317, =OΣ 15, a 0″.15 pair which would have been rejected as a double star had Burnham not succeeded in measuring it with the 36-inch in 1890. Several measures have since been made upon it with the largest refractors, but, notwithstanding its closeness, the pair appears to be fixed.

The Flower Observatory.
April 3, 1920.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors. E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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PHOTOGRAPHIC DETERMINATIONS OF PARALLAXES AT THE ALLEGHENY OBSERVATORY.

Note. In Volume 4, *Publications of the Allegheny Observatory*, the writer of this note published the parallaxes of fifty stars, determined with the aid of the Thaw Refractor. These results were printed and distributed in 1917. Since that time the distances of more than 300 additional stars have been determined by various members of the observatory staff. In order to make these results immediately available, the Editor of the *Journal* has agreed to publish a summary of them here. The details will be given in full in subsequent numbers of the *Publications of the Allegheny Observatory*. In about two-thirds of the cases four comparison stars have been employed; in the others, three. The average number of plates for each star is fifteen. The average probable error of the parallaxes is 0″.0081. To obtain absolute values we should add 0″.005 to the relative parallaxes in these summaries. The serial numbers attached to the stars are in continuation to those assigned to the first fifty. It should be mentioned that it has been found necessary to reject very few plates indeed on account of discordance, not more than one in four hundred for the present lists. We are under deep obligations to PROFESSOR BAILEY, MISS CANNON, PROFESSOR PORTER and PROFESSOR BOSS for information concerning spectra, magnitudes and proper-motions that would not have been available otherwise.

January, 1920. FRANK SCHLESINGER.

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
	STARS 51 TO 81, BY CHARLES J. HUDSON								
		h m	° ′	°		″	″	″	″
51	λ *Aurigæ*	5 12	+40 1	+39 1248	4.8 G0	0.84	+.062	±.007	±.019
52	o *Aurigæ*	38	+49 47	+49 1398	5.5 A0	.009	+.012	7	20
53	4 *Geminorum*	6 4	+23 1	+23 1232	6.7 B9	.014	.000	7	20
54	OΣ 149	30	+27 21	+27 1164	6.9 G0	.06	+.021	4	10
55	ξ *Geminorum*	40	+13 0	+13 1396	3.4 F5	.23	+.055	8	23
56	18 *Monocerotis*	43	+ 2 31	+ 2 1397	4.7 K0	.03	+.019	10	25
57	τ *Geminorum*	7 5	+30 25	+30 1439	4.5 K0	.05	+.005	10	25
58	δ *Geminorum*	14	+22 10	+22 1645	3.5 F0	.02	+.055	7	19
59	6 *Canis Minoris*	24	+12 13	+12 1567	4.8 K0	.02	+.019	8	19
60	υ *Geminorum*	30	+27 7	+27 1424	4.2 K5	.12	+.010	10	25
61	σ *Geminorum*	37	+29 8	+29 1590	4.3 K0	.24	+.015	6	13
62	κ *Geminorum*	38	+24 38	+24 1759	3.7 G5	.06	+.025	7	20
63	13 *Canis Minoris*	7 57	+ 2 37	+ 2 1854	4.5 K0	.10	+.015	7	20

No	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
		h m	° ′	°		″	″	″	″
64	27 *Lyncis*	8 1	+51 48	+51 1391	4.9 A2	0.05	−.017	±.011	±.032
65	31 *Lyncis*	16	+43 30	+43 1815	4.4 K0	.11	+.025	7	22
66	σ *Hydræ*	34	+ 3 42	+ 3 2026	4.5 K5	.02	+.014	12	32
67	γ *Cancri*	38	+21 50	+21 1895	4.7 A0	.11	+.006	6	15
68	δ *Cancri*	39	+18 31	+18 2027	4.2 K0	.24	−.012	12	32
69	θ *Hydræ*	9 9	+ 2 44	+ 2 2167	3.8 A0	.34	+.012	7	20
70	κ *Leonis*	19	+26 37	+26 1939	4.6 K0	.06	−.009	5	15
71	Σ 2725 (brighter)	20 42	+15 32	+15 4251	7.3	.12	+.025	9	22
72	Σ 2725 (fainter)	42	+15 32	......	8.0	.10	−.002	11	28
	Mean		....	....	....	...	+.014	7	...
73	ξ *Cygni*	21 1	+43 32	+43 3800	3.9 K5	.011	−.008	6	16
74	τ *Cygni*	11	+37 37	+37 4240	3.8 F0	.45	+.058	10	29
75	ι *Pegasi*	22 2	+24 51	+24 4533	4.0 F5	.30	+.067	8	26
76	ε *Cephei*	11	+56 33	+56 2741	4.2 A5	.45	+.027	11	27
77	5 *Lacertæ*	25	+47 12	+46 3719	4.6 K0	.02	.000	8	25
78	μ *Pegasi*	45	+24 4	+23 4615	3.7 K0	.16	+.043	6	18
79	β 382	49	+44 13	+43 4331	5.6 A0	.013	+.013	12	31
80	φ *Pegasi*	23 47	+18 34	+18 5231	5.2 Ma	.05	+.009	8	19
81	ρ *Cassiopeiæ*	49	+56 57	+56 3111	4.8 F8p	.004	+.013	11	26

Stars 82 to 130 by Frank Schlesinger, Lois Denton and Others

No	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
82	α *Arietis*	2 2	+22 59	+22 306	2.2 K2	.24	+.029	±.006	±.017
83	6 *Persei*	7	+50 36	+50 481	5.4 G5	.39	+.007	7	22
84	73 *Ceti*	23	+ 8 1	+ 7 388	4.3 A0	.04	+.017	9	26
85	86 γ *Ceti*	38	+ 2 49	+ 2 422	3.6 A0	.21	+.014	8	20
86	87 μ *Ceti*	40	+ 9 42	+ 9 359	4.4 A5	.29	+.028	7	20
87	17 *Persei*	45	+34 39	+34 527	4.7 K5	.08	+.005	10	28
88	27 κ *Persei*	3 3	+44 29	+44 631	4.0 K0	.24	+.032	7	19
89	*B. D.* +33° 619	12	+33 51	+33 619	4.9 K0	.015	+.007	6	17
90	35 σ *Persei*	24	+47 39	+47 843	4.6 K0	.021	+.008	8	22
91	74 ε *Tauri*	4 23	+18 58	+18 640	3.6 K0	.12	+.023	10	30
92	32 ν *Aurigæ*	5 45	+39 7	+39 1429	4.2 K0	.007	+.017	7	21
93	1 *Geminorum*	58	+23 16	+23 1170	4.3 G5	.11	+.020	9	27
94	8 *Monocerotis*	6 18	+ 4 39	+ 4 1236	4.5 A5	.009	+.016	6	19
95	43 ζ *Geminorum*	58	+20 43	+20 1687	var. G0	.007	−.005	10	25
96	54 λ *Geminorum*	7 12	+16 43	+16 1443	3.6 A2	.07	+.033	9	24
97	60 ι *Geminorum*	20	+28 0	+28 1385	3.9 K0	.14	+.035	8	25
98	17 β *Cancri*	8 11	+ 9 30	+ 9 1917	3.8 K2	.07	−.003	9	26
99	5 β *Virginis*	11 45	+ 2 20	+ 2 2489	3.8 F8	.79	+.096	6	15
100	67 *Ursæ Majoris*	57	+43 36	+43 2179	5.1 A3	.32	+.008	7	20
101	42 *Comæ*	13 5	+18 3	+18 2697	4.5 F5	.45	+.064	14	31

No.	Name	α 1900	δ (1900)	Durchmusterung Number	Visual Mag and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
		h m	° ′				″	″	″
102	8 γ *Coronæ*	15 39	+26 37	+26 2722	3.9 A0	0.10	+.024	±.010	±.025
103	16 τ *Coronæ*	16 5	+36 45	+36 2699	4.9 G2	.32	+.021	10	21
104	19 ξ *Coronæ*	18	+31 7	+31 2845	4.7 G5	.13	+.009	8	19
105	*B. D.* +31 2873	33	+31 9	+31 2873	7.3 F8	.18	+.007	9	22
106	40 ζ *Herculis*	38	+31 47	+31 2884	3.0 G0	.70	+.114	12	32
107	*B. D.* +0° 3593	16 48	+ 0 11	+ 0 3593	6.8 G5	1.66	+.079	11	27
108	65 δ *Herculis*	17 11	+24 57	+25 3221	3.2 A0	.16	+.029	7	19
109	68 *u Herculis*	14	+33 12	+33 2864	var. B3	.021	−.023	10	28
110	26 *Draconis*	34	+61 57	+61 1678	5.3 F0	.57	+.046	9	27
111	84 *Herculis*	39	+24 22	+24 3237	5.7 F0	.13	+.001	9	24
112	86 μ *Herculis*	43	+27 47	+27 2888	3.5 G5	.82	+.104	8	24
113	30 *Draconis*	47	+50 48	+50 2468	5.2 A0	.21	−.012	7	19
114	33 γ *Draconis*	54	+51 30	+51 2282	2.4 K5	.026	+.011	8	22
115	*B. D.* +4° 3589	18 1	+ 4 39	+ 4 3589	6.8 G0	.30	+.048	9	28
116	72 *Ophiuchi*	3	+ 9 33	+ 9 3564	3.7 A2	.10	+.032	8	22
117	110 *Herculis*	41	+20 27	+20 3926	4.3 F5	.34	+.040	11	28
118	13 θ *Cygni*	19 34	+49 59	+49 3062	4.6 F5	.25	+.057	8	19
119	β 658	40	+26 54	+26 3654	6.5 K0	.06	−.015	9	26
120	15 *Cygni*	41	+37 7	+37 3586	5.0 K0	.08	+.015	9	24
121	37 γ *Cygni*	20 19	+39 56	+39 4159	2.3 F8p	.006	−.022	8	22
122	58 ν *Cygni*	53	+40 47	+40 4364	4.0 A0	.027	−.005	8	22
123	46 ξ *Pegasi*	22 42	+11 40	+11 4875	4.3 F5	.55	+.044	9	24
124	47 λ *Pegasi*	42	+23 2	+22 4709	4.1 K0	.06	+.032	11	28
125	3 *Andromedæ*	23 0	+49 30	+49 4028	4.9 K0	.23	−.009	11	29
126	7 *Andromedæ*	8	+48 52	+48 3964	4.6 F0	.14	+.053	13	34
127	6 γ *Piscium*	12	+ 2 44	+ 2 4648	3.8 K0	.76	+.018	10	26
128	62 τ *Pegasi*	16	+23 12	+22 4810	4.6 A5	.048	+.031	9	25
129	68 υ *Pegasi*	20	+22 51	+22 4833	4.6 G0	.19	+.033	9	21
130	85 *Pegasi*	23 57	+26 33	+26 4734	5.8 G0	1.29	+.084	12	32

Stars 131 to 160 by Frank Schlesinger and Mary Nail

No.	Name	α 1900	δ (1900)	Durchmusterung Number	Visual Mag and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
131	Anonymous	0 0	+45 14			.86	+.099	±.010	±.023
132	OΣ 547 (prec.)	0 0	+45 16	+45 4408	8.9 K5		+.092	7	16
133	OΣ 547 (fol.)	0 0	+45 15		8.9 K5		+.121	9	23
	Mean					.86	+.103	5	
134	ε *Andromedæ*	0 33	+28 46	+28 103	4.5 G5	.34	+.033	6	19
135	β *Trianguli*	2 4	+34 31	+34 381	3.1 A5	.16	+.006	6	18
136	54 χ *Orionis*	5 48	+20 15	+20 1162	4.6 F8	.21	+.096	10	29
137	*B. D.* +13° 1036	5 50	+13 55	+13 1036	6.5 G5	.48	+.083	8	20
138	71 *Orionis*	6 9	+19 11	+19 1270	5.2 F5	.22	+.034	7	21
139	κ *Aurigæ*	6 9	+29 32	+29 1154	4.4 K0	.27	+.010	8	23

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
		h m	° ′	°		″	″	″	″
140	56 *Aurigæ*	6 40	+43 41	+43 1595	5.3 F5	0.16	+.072	±.007	±.020
141	*B. D.* +21° 1596	7 21	+21 44	+21 1596	6.4 F5	.31	+.035	7	22
142	10 *Ursæ Majoris*	8 54	+42 11	+42 1956	4.1 F5	.50	+.067	6	18
143	*μ Leonis*	9 47	+26 29	+26 2019	4.1 K0	.23	+.020	9	23
144	*B. D.* +4° 3195	16 26	+ 4 26	+ 4 3195	7.3 F6	1.45	+.029	6	15
145	41 *Herculis*	16 40	+ 6 17	+ 6 3288	6.7 G5	.35	+.028	8	20
146	*B. D.* +63° 1439	18 34	+63 37	+63 1439	8.1 G5	.25	+.023	8	19
147	*B. D.* +10° 3665	18 44	+10 39	+10 3665	8.0 K0	.46	+.045	11	25
148	*B. D.* +17° 3779	18 52	+17 59	+17 3779	5.7 A0	.18	.000	8	21
149	*ι Cygni*	19 27	+51 31	+51 2605	3.9 A2	.13	−.006	7	18
150	*o*¹ *Cygni*	20 10	+46 31	+46 2881	5.0 A2	.021	−.011	10	30
151	*o*² *Cygni*	20 10	+46 26	+46 2882	4.0 K0	.006	−.013	9	25
152	*B. D.* +41° 3799	20 29	+41 33	+41 3799	7.0 G5	.47	+.021	8	21
153	*B. D.* +57° 2240	20 43	+57 13	+57 2240	4.6 G0	.24	+.040	5	14
154	*B. D.* +17° 4519	21 7	+17 21	+17 4519	7.3 F5	.91	+.038	4	11
155	*B. D.* +45° 3561	21 26	+45 27	+45 3561	7.9 G0	.56	+.020	11	29
156	*ρ Cygni*	21 30	+45 9	+44 3865	4.2 K0	.10	−.017	9	21
157	*B. D.* +53° 2735	21 51	+53 28	+53 2735	6.9 F5	.17	+.009	6	18
158	*B. D.* +56° 2727	22 8	+56 21	+56 2727	5.4 F8	.27	+.022	7	19
159	*β Pegasi*	22 59	+27 32	+27 4480	2.6 Mb	.23	+.018	10	26
160	*λ Andromedæ*	23 33	+45 55	+45 4283	4.0 K0	.45	+.044	5	12

Stars 161 to 185 by Frank Schlesinger and Harriet Knudsen

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
161	*χ Pegasi*	0 9	+19 39	+19 27	4.9 Ma	.10	+.010	±.006	±.019
162	*υ Piscium*	1 14	+26 44	+26 220	4.7 A2	.029	+.011	7	21
163	*γ Andromedæ* (prec)	1 58	+41 51	+41 395	2.3 K0	.07	−.003	10	31
164	*γ Andromedæ* (fol)	1 58	+41 51	+41 395	5.1 A0	.07	−.005	7	22
...	Mean		.. ..	.. ....	....	..	−.004	6	..
165	16 *Persei*	2 44	+37 54	+37 646	4.3 F0	.22	+.017	8	26
166	*o Tauri*	3 19	+ 8 41	+ 8 511	3.8 G5	.10	+.001	6	18
167	40 *Orionis*	5 31	+ 9 14	+ 9 898	4.4 K0	.32	+.034	8	22
168	*B. D.* +5° 1168	6 12	+ 5 8	+ 5 1168	5.8 F8	.28	+.046	8	21
169	8 *Lyncis*	6 29	+61 34	+61 893	6.0 F0	.019	+.023	9	24
170	*B. D.* +21° 1528	7 4	+21 25	+21 1528	6.5 F8	.51	+.022	6	16
171	18 *Lyncis*	7 7	+59 49	+59 1065	5.3 G5	.27	+.031	6	18
172	38 *Lyncis*	9 13	+37 14	+37 1965	3.8 A0	.13	+.026	8	24
173	35 *Leonis*	10 11	+24 0	+24 2207	5.9 G0	.21	+.038	7	19
174	*o Virginis*	12 0	+ 9 17	+ 9 2583	4.2 G5	.22	+.034	6	17
175	8 *Canum Ven.*	12 29	+41 54	+42 2321	4.3 G0	.75	+.109	6	16
176	*B. D.* +10° 2637	14 5	+10 43	+10 2637	7.9 G0	.17	+.023	9	23
177	*ξ Bootis*	14 47	+19 31	+19 2870	4.6 K5	.17	+.147	7	19

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
		h m	° ′	°		″	″	″	″
178	45 *Bootis*	15 3	+25 16	+25 2873	5.0 A5	0.27	+.054	±.006	±.015
179	*B. D.* +25° 2874	15 3	+25 18	+25 2874	9.9 K5	.96	+.061	10	19
180	*σ Serpentis*	16 17	+ 1 16	+ 1 3215	4.8 F0	.17	+.026	10	28
181	*B. D.* +8° 3689	18 21	+ 8 44	+ 8 3689	7.7 G5	.54	+.026	9	21
182	*B. D.* +52° 2294	18 49	+52 51	+52 2294	5.6 G5	.29	+.043	7	20
183	*σ Cygni*	21 13	+38 59	+38 4431	4.3 B8p	.008	−.007	9	24
184	72 *Cygni*	21 31	+38 5	+37 4359	5.0 K0	.15	+.012	10	27
185	16 *Cephei*	21 58	+72 42	+72 1009	5.2 F0	.18	+.033	9	24
Stars 186 to 213 by Frank Schlesinger and Florence Stocker									
186	*β Cassiopeiæ*	0 4	+58 36	+58 3	2.4 F5	.56	+.074	±.011	±.026
187	*η Cassiopeiæ*	0 43	+57 17	+57 150	3.6 F8	1.24	+.173	6	12
188	*α Ceti*	2 57	+ 3 42	+ 3 419	2.8 Ma	.08	−.001	5	12
189	*λ Tauri*	3 55	+12 12	+12 539	var. B3	.015	−.012	8	20
190	*ζ Aurigæ*	4 55	+40 56	+40 1142	3.9 K0	.033	−.003	5	16
191	16 *Virginis*	12 15	+ 3 52	+ 4 2604	5.1 K0	.30	−.011	8	21
192	*Piazzi* 243	12 56	+18 55	+19 2622	6.1 G0	.25	+.017	7	17
193	70 *Virginis*	13 24	+14 19	+14 2621	5.2 F0	.63	+.032	8	23
194	*τ Bootis*	13 43	+17 57	+18 2782	4.5 F5	.48	+.043	7	16
195	*κ Bootis* (fainter)	14 10	+52 15	....	6.6	.07	+.022	9	16
196	*κ Bootis* (brighter)	14 10	+52 15	+52 1782	4.6	.07	+.018	11	27
...	Mean	.....	......	....	A5	....	+.020	7	....
197	*λ Bootis*	14 13	+46 33	+46 1949	4.3 A0	.24	+.036	9	25
198	*θ Bootis*	14 22	+52 19	+52 1804	4.1 F8	.47	+.062	11	25
199	*β Serpentis*	15 42	+15 44	+15 2911	3.7 A2	.09	+.031	8	18
200	*Groombridge* 2354	16 27	+48 11	+48 2400	....	.30	−.004	8	21
201	*η Herculis*	16 39	+39 7	+39 3029	3.6 K0	.10	+.053	9	26
202	*Lalande* 31528	17 15	+ 9 34	+ 9 3366	....	.31	−.022	7	18
203	*β Draconis*	17 28	+52 23	+52 2065	3.0 G0	.012	+.014	8	24
204	*ν Draconis* (prec.)	17 30	+55 15	+55 1944	5.0 A5	.16	+.005	13	36
205	*ν Draconis* (fol.)	17 30	+55 15	+55 1945	5.0 A5	.17	+.022	10	28
...	Mean	.....	......	....	....	....	+.016	8	.....
206	*Piazzi* 368	18 2	+ 8 52	+ 8 3581	....	.15	+.004	9	21
207	*Groombridge* 2527	18 8	+54 15	+54 1950	5.9 G5	.28	+.007	7	18
208	*δ Draconis*	19 13	+67 29	+67 1129	3.2 K0	.13	+.030	10	25
209	25 *Aquilæ*	19 13	+11 25	+11 3790	5.1 A0	.010	+.006	5	14
210	*Groombridge* 2809	19 14	+46 49	+46 2658	6.0 F0	.28	+.013	11	29
211	16 *Cygni* (brighter)	19 39	+50 18	+50 2847	6.3	.21	+.043	6	16
212	16 *Cygni* (fainter)	19 39	+50 17	+50 2848	6.4	.20	+.021	12	31
..	Mean	....	......	....	F0	....	+.038	5	.....
213	*κ Pegasi*	21 40	+25 11	+24 4463	4.3 F5	.037	+.021	7	20

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec.	Total Proper-Motion	Relative Parallax and Probable Error		Prob. Error for one Good Plate
	Stars 214 to 236 by Robert Trumpler								
		h m	° ′	°		″	″	″	″
214	4 *Camelopardi*	4 40	+56 35	+56 973	5.4 A2	0.16	+.008	±.007	±.022
215	*o Ursa Majoris*	8 22	+61 3	+61 1054	3.5 G0	.17	−.004	6	19
216	36 *Ursæ Majoris*	10 24	+56 30	+56 1459	4.8 F5	.18	+.070	7	19
217	*Groombridge* 1658	10 27	+40 56	+41 2101	4.8 F	.14	+.023	7	19
218	*γ Comæ Berenices*	12 22	+28 49	+29 2288	4.6 K	.12	−.003	5	17
219	*δ Virginis*	12 51	+ 3 56	+ 4 2669	3.7 Ma	.48	+.013	7	17
220	*β* 612	13 35	+11 15	+11 2589	5.5 A	.11	−.001	8	23
221	*Piazzi* 194	13 42	+ 6 51	+ 7 2690	6.3 F5	.50	+.023	6	17
222	*B. D.* +7° 2692	13 43	+ 6 53	+ 7 2692	10.0	.50	+.026	8	25
	Mean						+.024	5	
223	*ρ Bootis*	14 28	+30 49	+31 2628	3.8 K0	.15	+.031	8	24
224	*ε Bootis* (prec)	14 41	+27 30	+27 2417	5.1		+.014	11	28
225	*ε Bootis* (fol.)	14 41	+27 30	+27 2417	2.7 K0	.05	+.006	9	22
	Mean						+.009	7	
226	*β Bootis*	14 58	+40 47	+40 2840	3.6 G5	.06	+.013	8	22
227	*δ Bootis*	15 11	+33 41	+33 2561	3.5 K0	.16	+.026	9	22
228	5 *Serpentis*	15 14	+ 2 9	+ 2 2944	5.2 G	.64	+.030	8	24
229	*ι Draconis*	15 23	+59 19	+59 1654	3.5 K0	.01	+.020	10	25
230	*λ Serpentis*	15 42	+ 7 40	+ 7 3023	4.4 G	.24	+.081	8	21
231	*δ Coronæ Borealis*	15 45	+26 22	+26 2737	4.7 G5	.11	+.008	8	22
232	*κ Coronæ Borealis*	15 47	+35 58	+36 2652	4.8 Mb	.36	+.025	5	15
233	*Groombridge* 3100 (prec)	20 11	+52 49	+52 2657	7.0 F5	.18	+.007	9	27
234	*Groombridge* 3100 (fol)	20 11	+52 49		9.1		+.015	15	36
	Mean						+.009	8	
235	61[1] *Cygni*	21 3	+38 15	+38 4343	5.6	5.26	+.282	9	29
236	61[2] *Cygni*	21 3	+38 15	+38 4344	6.3	5.14	+.286	7	23
	Mean				K5		+.285	5	
	Stars 237 to 285 by Frank Schlesinger, Lois Denton and Marie Bender								
237	*δ Andromedæ*	0 34	+30 19	+30 91	3.5 K2	.17	+.015	±.008	±.023
238	*ζ Andromedæ*	42	+23 43	+23 106	4.3 K0	.13	+.026	8	25
239	*μ Andromedæ*	51	+37 57	+37 175	3.9 A2	.16	+.040	9	27
240	28 *Cassiopeiæ*	51	+58 38	+58 138	4.8 K0	.10	+.068	6	15
241	*η Andromedæ*	52	+22 53	+22 153	4.6 G5	.06	+.006	5	15
242	*χ Piscium*	1 6	+20 30	+20 172	4.9 K0	.023	+.008	5	15
243	*ζ Piscium* (prec)	9	+ 7 3	+ 6 174	5.6 A5	.15	+.021	12	29
244	*ζ Piscium* (fol)	9	+ 7 3	+ 6 175	6.5 F8	.15	+.018	7	17
	Mean						+.019	6	
245	38 *Cassiopeiæ*	1 24	+69 45	+69 102	6.0 F5	.16	+.034	8	21

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Mag. and Spec	Total Proper-Motion	Relative Parallax and Probable Error		Prob Error for one Good Plate
		h m	° ′	°		″	″	″	″
246	*η Piscium*	1 26	+11 50	+14 231	3.7 G5	0.034	−.015	±.005	±.016
247	*χ Cassiopeia*	27	+58 43	+58 260	4.9 K0	.038	+.015	5	15
248	*υ Persei* . .	32	+48 7	+47 467	3.8 K0	.13	+.029	10	27
249	*ν Piscium* .	36	+ 4 59	+ 4 293	4.7 K0	.018	+.050	7	18
250	65 *Andromedæ*	2 19	+49 50	+49 656	4.9 K5	.032	.000	6	18
251	*θ Persei* . . .	37	+48 48	+48 746	4.2 F8	.35	+.071	6	20
252	*ζ Arietis*	3 9	+20 40	+20 527	5.0 A0	.08	+.012	4	10
253	*ν Persei* . .	38	+42 16	+42 815	3.9 F5	.008	+.004	7	18
254	*ν Tauri* .	58	+ 5 43	+ 5 581	3.9 A0	.009	+.009	9	27
255	*β* 883 . .	4 46	+10 54	+10 654	7.0 F5	.	+.036	5	16
256	*τ Aurigæ*	5 42	+39 9	+39 1418	4.6 K0	.035	+.009	7	22
257	*Lalande* 11471	59	+35 24	+35 1334	6.1 G0	.33	+.043	9	29
258	*β* 895 . . .	6 13	+28 29	+28 1078	7.2 A3	.	+.001	6	17
259	6 *Lyncis* .	22	+58 14	+58 932	6.0 G5	.33	+.014	8	23
260	*Piazzi* 305	57	+29 30	+29 1441	6.0 F8	.84	+.053	9	24
261	*α Geminorum* (prec)	7 28	+32 6	.	2.8 A0	.	+.054	7	25
262	*α Geminorum* (fol.) .	28	+32 6		2.0 A0	.	+.085	7	24
.	Mean		. .	+32 1581	. . .	.11	+.070	5	
263	*ο Geminorum* . . .	33	+34 49	+34 1649	4.9 F0	.12	+.028	9	24
264	*Lalande* 15565	54	+29 31	+29 1664	6.9 G0	1.17	+.042	6	19
265	14 *Cancri*	8 4	+25 49	+25 1865	5.8 G5	.36	+.031	10	25
266	18 *Cancri* . .	14	+27 33	+27 1589	5.2 F5	.39	+.060	9	25
267	4 *Ursæ Majoris* .	31	+64 40	+64 698	4.8 K0	.05	+.013	10	31
268	55 *Cancri*	47	+28 43	+28 1660	6.1 K0	.54	+.069	6	15
269	*ζ Hydræ* . .	50	+ 6 20	+ 6 2060	3.3 K0	.10	+.024	8	22
270	11 *Leonis Minoris*	9 30	+36 16	+36 1979	5.5 K0	.75	+.117	7	20
271	78 *Ursæ Majoris* . .	12 56	+56 54	+57 1408	4.9 F0	.10	+.026	11	28
272	59 *Virginis*	13 12	+ 9 57	+10 2531	5.2 F0	.38	+.070	10	25
273	24 *Bootis*	14 25	+50 18	+50 2084	5.6 G5	.31	+.018	11	27
274	*Groombridge* 2152	45	+38 13	+38 2593	6.0 F0	.27	+.010	10	25
275	*α Serpentis* .	15 39	+ 6 44	+ 6 3088	2.8 K0	.14	+.046	11	25
276	*ε Serpentis*	46	+ 4 47	+ 4 3069	3.8 A0	.14	+.030	7	19
277	39 *Serpentis* .	49	+13 31	+13 3024	6.2 G0	.58	+.021	9	22
278	*ρ Coronæ Borealis*	57	+33 37	+33 2663	5.4 F0	.81	+.045	8	20
279	*Lalande* 29437 . .	16 4	+ 6 40	+ 6 3169	6.0 F5	.76	+.012	8	22
280	Σ 2107	48	+28 50	+28 2624	6.5 F5	. . .	+.028	10	28
281	*Groombridge* 2389	50	+43 0	+43 2659	6.7 G0	.35	+.026	9	26
282	*Lalande* 31065	17 0	+ 0 51	+ 0 3629	5.9 F8	.32	+.034	6	15
283	*α Herculis* (prec)	10	+14 30	. . . .	3.5	.029	−.025	9	25
284	*α Herculis* (fol)	10	+14 30	.	5.4	.032	−.009	10	27
	Mean		. . .	+14 3207	Mb	. .	−.018	7	
285	*β* 637 .	18 5	+ 3 6	+ 3 3613	5.7 F0	.21	+.076	8	20

Stars 286 to 319, by F. Henroteau

For this series the average probable error is ″.0085, the average number of plates is 14.3, and the average number of comparison stars is 3.5.

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Magn. and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error
		h m	° ′	°		″	″ ″
286	*α Trianguli*	1 47	+29 6	+28 312	3.6 F5	.23	+.045 ±.007
287	*γ Persei*	2 58	+53 7	+52 654	3.1 *	.012	+.010 6
288	*Lalande* 6772	3 37	+42 18	+42 812	7.4 G0	.42	+.026 8
289	104 *Tauri*	5 2	+18 31	+18 779	5.0 G0	.54	+.055 8
290	18 *Camelopardi*	24	+57 9	+57 889	6.5 G0	.25	+.009 6
291	*Groombridge* 990	30	+51 23	+51 1094	7.9 K0	.56	+.035 6
292	*Piazzi* 146	33	+53 26	+53 934	6.4 K0	.51	+.083 6
293	*Lalande* 10797	39	+37 15	+37 1312	7.3 K0	.71	+.086 6
294	*δ Aurigæ*	5 51	+54 17	+54 970	3.9 K0	.15	+.023 9
295	*Lalande* 16933	8 32	+26 24	+26 1816	7.6 G5	.24	+.022 10
296	81 *Cancri*	9 7	+15 24	+15 2003	6.4 G0	.57	+.065 8
297	*θ Ursæ Majoris*	26	+52 8	+52 1401	3.3 F8	1.09	+.057 9
298	*Lalande* 18721	27	+27 26	+27 1775	7.1 K0	.28	+.050 9
299	20 *Leonis Minoris*	55	+32 25	+32 1964	5.6 F2	.68	+.069 9
300	*Groombridge* 1603	9 58	+38 30	+38 2096	6.8 F5	.17	+.027 10
301	37 *Ursæ Majoris*	10 29	+57 36	+57 1277	5.2 F0	.07	+.029 11
302	47 *Ursæ Majoris*	10 54	+40 58	+41 2147	5.1 F0	.32	+.075 10
303	*Lalande* 22908	12 8	+11 24	+11 2439	7.9 G5	.59	+.023 10
304	10 *Canum Venaticorum*	40	+39 49	+40 2570	6.0 F0	.38	+.058 5
305	*Lalande* 23900	12 44	+25 23	+25 2568	6.4 F2	.37	+.021 12
306	*Piazzi* 200	13 42	+56 23	+56 1683	6.4 F0	.37	+.022 8
307	*B.D.* +19° 2881	14 49	+19 33	+19 2881	6.0 K0	.48	+.081 8
308	*Lalande* 27922	15 15	− 8 18	− 8 3949	7.9 F8	.21	−.010 9
309	*Groombridge* 2273	15 42	+53 18	+53 1806	7.3 G5	.26	+.010 10
310	12 *Ophiuchi*	16 31	− 2 7	− 1 3220	5.9 F0	.55	+.083 9
311	35 *Draconis*	17 54	+76 59	+76 667	5.0 F5	.24	+.033 11
312	*B.D.* +8° 3692	18 22	+ 8 34	+ 8 3692	8.5 G5	.51	+.037 12
313	*Weisse* 1064	18 37	+31 28	+31 3330	8.7 K2	.82	+.028 8
314	*Lalande* 39866	20 35	+ 4 37	+ 4 4510	8.4 K5	.84	+.045 11
315	56 *Cygni*	47	+43 41	+43 3739	5.1 A8	.18	+.029 6
316	*Fedorenko* 3638	20 52	+74 23	+74 889	7.8 G5	.69	+.037 9
317	*ν Pegasi*	22 1	+ 4 34	+ 4 4800	4.9 K0	.14	+.010 9
318	*δ Cephei*	25	+57 54	+57 2548	Var. G0	.020	+.006 6
319	*ι Cephei*	22 46	+65 40	+65 1814	3.7 K0	.14	+.027 7

*The spectrum of *γ Persei* is composite, F5 and A3.

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ON THE REAL MOTIONS OF THE STARS (Paper 2),

Systematic Corrections to Stellar Parallaxes,

By BENJAMIN BOSS.

In *Astronomical Journal* No. 736 the real motions of the stars were treated, solely utilizing those stars whose parallaxes were observed by ADAMS and JOY as published in *Ap. J.*, Vol. XLVI, No. 5. It seemed desirable to extend the investigation, including all available parallax results.

Some method had to be devised whereby the parallaxes might be combined in as nearly a uniform system as might be derived from a treatment of the existing data. The present discussion is no wise intended to furnish definitive results, as the gradual accumulation of parallaxes will considerably alter the findings, but it is designed to furnish the means whereby parallaxes of the same star may be combined for the present purpose of discussing the real motions of the stars.

The results of the first approximation to a system were presented at the Harvard meeting of the *American Astronomical Society* 1918. The parallax observers immediately and very generously offered their unpublished data for inclusion in the discussion. Thus the value of the system has been greatly enhanced.

The following corrections for the mean parallaxes of comparison stars were applied to the listed authorities to reduce to absolute parallax.

Mount Wilson (Trig)	+″.002
Sproul	+ .004
Russell	+ .004
Yerkes	+ .004
McCormick	+ .004
Allegheny	+ .004

The results of the preliminary tests will not be given as they antedated the receipt of the unpublished parallaxes which have been used in the final solutions, but as they served to direct the method of attack for the final stages a few remarks should be made.

For the first tests three independent methods were resorted to to obtain the constant correction to each authority. The first depended upon the residual corrections obtained by forming the difference Mt. Wilson (Spectroscopic) − author. For the second test an arbitrary system of weights was adopted based on the published probable errors of individual parallaxes.

p. e.	wt.
″.000 − ″.010	= 7
.011 − .015	= 6
.016 − .020	= 5
.021 − .030	= 4
.031 − .040	= 3
.041 − .060	= 2
.061 −	= 1

Employing only those stars where three or more authorities had determined the parallax, means by weight were taken. The rule was observed that no stars should be accepted where the weight of any one observer exceeded four times the combined weights of the others.

For the third test it was assumed that the probable error assigned to each parallax by the author represented the real probable error of the determination, and it was further assumed that the weights are inversely proportional to the square of the probable errors. The weight corresponding to a probable error of ±″.010 was adopted as the unit of weight, and 4.0 was placed as the upper limit. While it was recognized that the weight of the spectroscopic determinations of parallaxes at Mt. Wilson varied with the size of the parallax, in the absence of any definite knowledge of its trend, a uniform weight of 0.9 was assigned.

The constant correction to each observer derived through the three independent methods agreed re-

markably well, indicating that the system of weighting would effect little change in the results.

When the residuals were plotted according to right ascension of the stars, it became manifest that a seasonal term would not account for the systematic variation in some cases, so a term depending upon 2α was introduced.

It was also evident that for the trigonometrical parallaxes the published probable errors very closely represent the true probable errors as obtained by the solution.

Therefore when the unpublished parallaxes became available for treatment a first approximation to a system was made following the methods of the third test, with a few alterations. All stars for which two parallax values are given were employed. The spectroscopic parallaxes received weight 1.0. For those authorities supplying a sufficient amount of material, hourly means by weights were taken to determine the systematic corrections dependent on right ascension. Weighted conditional equations of the following type were then formed.

$$pK + pA \sin\alpha + pB \cos\alpha + pC \sin 2\alpha + pD \cos 2\alpha = pv$$

The solution of the normal equations is given in Table I.

TABLE I

	K	sin α	cos α	sin 2α	cos 2α	comp. p. e.	obs. p. e.
	"	"	"	"	"	"	"
Mt. Wilson (Sp.)	−0.0056	−0.0009	−0.0016	+0.0004	+0.0002	±.0089	....
Mt. Wilson (Trig.)	−0.0087	+0.0015	+0.0031	−0.0005	−0.0015	.0030	±.0059
Allegheny	+0.0051	−0.0011	+0.0028	+0.0027	+0.0000	.0078	.0084
Lean. McCor.	+0.0010	+0.0014	−0.0025	−0.0032	−0.0023	.0088	.0090
Yerkes	+0.0056	+0.0005	+0.0018	+0.0035	+0.0068	.0108	.0103
Sproul	−0.0022	−0.0078	+0.0016	−0.0046	−0.0032	.0126	.0101
Chase (Yale)	+0.0075	+0.0004	−0.0048	−0.0051	+0.0060	.0236	.0346

The last two columns of Table I give the probable error of a single parallax derived after the application of the systematic correction, and the probable error assigned by the observer. In general the observed and computed values agree. It must be noted that the small probable error of the Mt. Wilson trigonometrical parallaxes as derived from this first approximation is partly due to the small weight assigned to the Mt. Wilson spectroscopic parallaxes for these stars. The trigonometrical series is mainly composed of stars of small proper-motion and consequently of small parallax. The weight of the spectroscopic parallaxes for these stars should have been very materially increased.

The residuals of the Mt. Wilson spectroscopic parallaxes were next examined for dependence of probable error upon the size of the parallax. The first group of 18 small parallaxes contained not a single plus residual. This led to an examination of the mean of the residuals taken with regard to sign and grouped according to the size of the parallaxes. Table II presents the results.

TABLE II

No. * * *	π	Mean v obs.	Mean v from curve
18	+".004	−".0072	−".0071
19	+ .009	− .0038	− .0054
42	+ .018	− .0045	− .0028
39	+ .026	+ .0027	− .0008
32	+ .033	+ .0005	+ .0006
31	+ .043	+ .0031	+ .0017
35	+ .061	+ .0029	+ .0028
32	+ .093	− .0002	+ .0038
15	+ .163	+ .0052	+ .0048
10	+ .281	+ .0055	+ .0059

The corrections shown in Table II are due to the uniform weight given to the spectroscopic parallaxes in the first approximation and were not used when solving for the second approximation.

Table III tabulates the curve drawn to represent the probable error of a single parallax depending upon the size of the parallax, and the weights assigned to the Mt. Wilson spectroscopic results for the second approximation to a system.

TABLE III

π	p. e.	wt.	π	p. e.	wt.
".00	±".0011	4.0	".06	±".0101	1.0
.01	.0036	4.0	.07	.0106	0.9
.02	.0057	3.1	.08	.0111	.8
.03	.0073	1.9	.09	.0116	.75
.04	.0085	1.4	.10	.0120	.69
.05	.0093	1.2	.15	.0140	.51

π	p. e.	wt.	π	p. e.	wt.
″.20	±″.0157	.41	″.40	±″.0215	.22
.25	.0172	.34	.45	.0229	.19
.30	.0187	.29	.50	.0243	.17
.35	.0201	.25			

The dependence of the probable error upon the number of plates taken in the determination of a parallax was then tested.

No. Plates	**	p. e.
1	8	±″.0073
2	54	.0074
3	145	.0090
4	33	.0091
5+	28	.0089

It would seem from the table that there is no gain in accuracy through the employment of numerous plates.

The next test considered classification of residuals according to spectral sequence from *M* giants to *M* dwarf.

	No. **	Mean of 5	p. e.
Mg	16	+″.0008	±″.0077
Kg	40	+ .0036	.0086
Gg	41	+ .0049	.0090
Fg	18	− .0018	.0063
Fd	64	− .0046	.0082
Gd	32	− .0002	.0074
Kd	45	− .0012	.0075
Md	13	− .0026	± .0178

The two strongest determinations of the mean of the residuals for the giant stars yield a decided positive value, while the three dwarf determinations yield a negative value. Though the evidence pointed toward a term dependent upon spectral type it was not introduced when solving for the second approximation.

The parallaxes of the Dearborn Observatory yielded only fourteen stars for comparison with other authorities, and because some of the residuals are unduly large no systematic correction is attempted at the present stage.

Table I furnishes the systematic corrections for seven observers. The terms dependent upon right ascension were determined to serve as a basis of comparison for the results obtained from the second approximation. Before solving for the second approximation only the constant term was applied to the absolute parallaxes. For those observers whose constant term is not contained in Table I, terms were assigned based upon the previous tests. The comparison between the computed and observed probable errors of Table I were used to form a set of factors by which the weights should be multiplied. For the second approximation the following corrections and weight factors were used—

Table IV

Authority	Corr.	Wt. factor
Mt. Wilson (Trig)	−″.009	1.0
Allegheny	+ .005	1.1
Lean. McCor.	+ .001	1.0
Yerkes	+ .006	0.95
Sproul	− .002	0.8
Yale (Chase)	+ .008	1.5
Yale (Smith)	− .012	0.33
Russell	.000	0.71
Washburn I	.000	0.46
Washburn II	− .006	0.57
Jost	− .021	1.5
Peter	− .004	1.1
Others	.000	0.5

Table I indicates a greater weight factor than 1.0 for the Mt. Wilson trigonometrical parallaxes, but, as was pointed out, the computed probable error was undoubtedly too low. Even with weight factor 1.0 the majority of this series of observations received the maximum of weight allowed, (4.0).

The second approximation was carried through precisely as was the first, after applying the corrections, and weights or weight factors of Tables III and IV. The resulting systematic corrections represented by Table V include the constant term applied before solving.

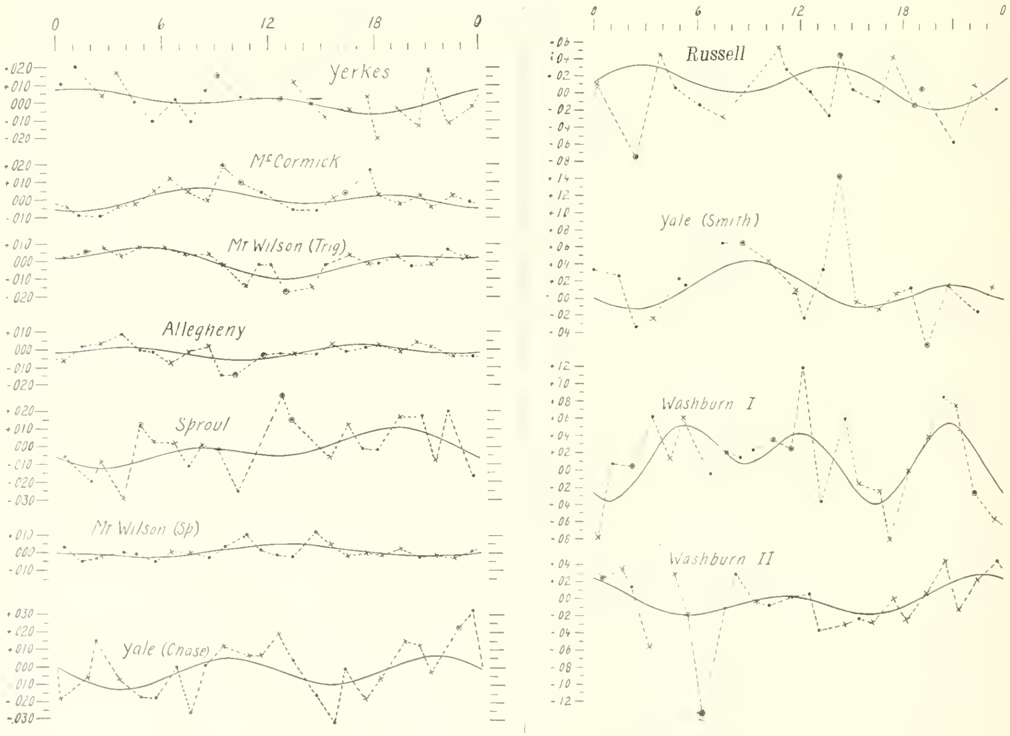
The probable errors of the terms in α and 2α are, in the mean, about one-half the size of the coefficients of the terms, for those authorities whose weight is considerable. While a greater degree of refinement is desirable the evidence indicates the possible existence of such terms in the parallax determinations. The trend of the coefficients follows that found in the first approximation; though individual coefficients have in some instances been considerably altered.

The accompanying diagrams represent the observed hourly means and the computed curve as derived from the second approximation. As there is no apparent reason why the Mt. Wilson spectroscopic

Table V

Author	K	sin α	cos α	sin 2α	cos 2α	sin 3α	cos 3α
	″	″	″	″	″		
Mt. Wilson (Sp.)	−0.0054 ± 5	−0.0009 ± 6	−0.0024 ± 7	+0.0006 ± 7	+0.0015 ± 7		
Mt. Wilson (Trig.)	−0.0094 ± 8	+0.0036 ± 11	+0.0057 ± 12	−0.0009 ± 11	−0.0039 ± 11		
Allegheny	+0.0034 ± 6	−0.0011 ± 8	+0.0018 ± 9	+0.0016 ± 8	−0.0019 ± 9		
McCormick	+0.0008 ± 8	+0.0011 ± 10	−0.0028 ± 12	−0.0029 ± 11	−0.0026 ± 11		
Yerkes	+0.0068 ± 14	+0.0035 ± 17	+0.0025 ± 19	+0.0014 ± 16	+0.0038 ± 18		
Sproul	−0.0038 ± 15	−0.0070 ± 16	−0.0004 ± 22	−0.0050 ± 19	−0.0039 ± 22		
Yale (Chase)	+0.0050 ± 18	−0.0014 ± 28	−0.0001 ± 24	−0.0082 ± 25	+0.0026 ± 26		
Yale (Smith)	−0.0023 ± 39	+0.0087 ± 56	−0.0107 ± 51	−0.0200 ± 59	−0.0012 ± 53		
Russell	+0.0109 ± 35	+0.0084 ± 52	−0.0048 ± 45	+0.0192 ± 57	+0.0070 ± 46	″	″
Washburn I	+0.0132 ± 73	+0.0114 ± 82	−0.0056 ± 104	−0.0188 ± 87	−0.0048 ± 94	−0.0194 ± 107	−0.0290 ± 82
Washburn II	−0.0010 ± 43	−0.0049 ± 55	+0.0115 ± 64	−0.0087 ± 59	+0.0139 ± 60		
Jost	−0.0180						
Peter	−0.0010						

The probable errors are expressed in units of the fourth decimal place.



⊙ Weakest weights of authority. × Strongest weights of authority.

parallaxes should have any seasonal term, the deviation of the computed curve from a straight line may be taken as an indication of the reliability of the system. There is only one region in which the curve deviates appreciably from a straight line, namely in the region around 13^h of right ascension. This is mainly due to the effect of the Mt. Wilson trigonometrical parallaxes in this region. A third approximation, introducing the systematic corrections of the Mt. Wilson trigonometrical curve, would undoubtedly flatten the curve.

Table VI — Systematic Corrections to Parallaxes

	Yerkes	Alleg.	McCorm.	Mt. W. (Trig.)	Sproul	Mt. W. (Sp.)	Russell	Yale (Chase)	Yale (Smith)	Wash. I	Wash. II
h	"	"	"	"	"	"	"	"	"	"	"
0	+.0131	+.0033	−.0055	−.0076	−.0081	−.0063	+.0131	+.0075	−.0118	−.0262	+.0190
1	+ 141	+ 40	− 62	− 68	− 119	− 64	+ 232	+ 27	− 191	− 371	+ 114
2	+ 138	+ 49	− 58	− 54	− 139	− 66	+ 310	− 16	− 239	− 240	+ 2
3	+ 124	+ 55	− 42	− 38	− 141	− 71	+ 326	− 43	− 237	+ 41	− 99
4	+ 104	+ 57	− 19	− 23	− 125	− 76	+ 288	− 46	− 178	+ 355	− 192
5	+ 82	+ 52	+ 8	− 16	− 98	− 79	+ 192	− 28	− 54	+ 517	− 246
6	+ 65	+ 41	+ 34	− 19	− 69	− 78	+ 123	+ 10	+ 54	+ 488	− 252
7	+ 56	+ 26	+ 51	− 36	− 47	− 73	+ 46	+ 51	+ 180	+ 325	− 218
8	+ 55	+ 10	+ 58	− 64	− 31	− 63	+ 4	+ 96	+ 276	+ 155	− 156
9	+ 61	− 3	+ 54	− 100	− 35	− 50	+ 10	+ 123	+ 317	+ 87	− 89
10	+ 65	− 11	+ 40	− 137	− 46	− 36	+ 62	+ 128	+ 295	+ 182	− 46
11	+ 79	− 11	+ 20	− 169	− 61	− 24	+ 134	+ 111	+ 194	+ 335	− 28
12	+ 81	− 3	0	− 190	− 73	− 16	+ 227	+ 77	+ 98	+ 430	− 40
13	+ 74	+ 11	− 14	− 197	− 75	− 13	+ 300	+ 37	− 30	+ 363	− 90
14	+ 60	+ 29	− 21	− 189	− 63	− 16	+ 310	0	− 111	+ 132	− 148
15	+ 40	+ 45	− 18	− 169	− 37	− 25	+ 276	− 21	− 209	− 153	− 203
16	+ 19	+ 58	− 8	− 142	− 1	− 37	+ 192	− 22	− 226	− 367	− 222
17	+ 2	+ 64	+ 4	− 115	+ 38	− 50	+ 76	0	− 170	− 357	− 210
18	− 4	+ 64	+ 13	− 92	+ 70	− 61	− 45	+ 38	− 126	− 128	− 154
19	+ 2	+ 52	+ 18	− 77	+ 86	− 68	− 142	+ 82	− 48	+ 211	− 62
20	+ 20	+ 46	+ 14	− 70	+ 83	− 72	− 188	+ 120	+ 12	+ 481	+ 46
21	+ 48	+ 38	0	− 71	+ 59	− 71	− 176	+ 141	+ 37	+ 553	+ 135
22	+ 80	+ 31	− 19	− 74	+ 18	− 69	− 106	+ 140	+ 17	+ 358	+ 204
23	+ 109	+ 30	− 39	− 78	− 32	− 65	+ 14	+ 117	− 62	+ 33	+ 228
24	+.0131	+.0033	−.0055	−.0076	−.0081	−.0063	+.0131	+.0075	−.0118	−.0262	+.0190

Jost −".018
Peter − .001

For those who prefer to ignore the terms in α and 2α the following constant corrections are tabulated.

Mt. Wilson (Sp.)	−".0057
Mt. Wilson (Trig.)	− .0093
Allegheny	+ .0039
McCormick	+ .0014
Yerkes	+ .0058
Sproul	− .0023
Yale (Chase)	+ .0065
Yale (Smith)	− .0064
Russell	+ .0148
Washburn I	+ .0090
Washburn II	− .0066
Jost	− .0180
Peter	− .0010

Table VI furnishes the corrections to the observed parallaxes as computed from the formulæ of Table V.

Table VII

		Obs. p.e	Comp. p. e.	* * *
Yerkes		±".0064	±".0081	22
		.0102	.0110	20
		.0150	.0130	23
	All	±".0106	±".0107	65
Allegheny		±".0056	±".0045	38
		.0070	.0063	31
		.0080	.0084	35
		.0090	.0109	28
		.0111	.0094	37
	All	±".0081	±".0078	169
McCormick		±".0062	±".0070	26
		.0080	.0087	27
		.0096	.0093	43
		.0119	.0126	26
	All	±".0090	±".0094	122

Mt. Wilson (Trig.)	±″.0034	±″.0027	19
	.0055	.0046	18
	.0089	.0066	18
All	±″.0059	±″.0046	55
Sproul	±″.0067	±″.0067	20
	.0102	.0146	20
	.0138	.0165	23
All	±″.0104	±″.0128	63
Russell	±″.0138	±″.0324	16
	.0322	.0276	19
All	±″.0238	±″.0298	35
Yale (Chase)	±″.0191	±″.0176	37
	.0288	.0206	30
	.0400	.0237	34
	.0492	.0368	35
All	±″.0342	±″.0248	136
Yale (Smith)	±″.0139	±″.0226	27
	.0250	.0354	33
All	±″.0200	±″.0297	60
Washburn I	±″.0300	±″.0314	29
	.0450	.0589	29
	.0622	.0697	26
All	±″.0452	±″.0527	84
Washburn II	±″.0239	±″.0286	28
	.0298	.0357	29
	.0370	.0403	33
All	±″.0306	±″.0352	90
Jost	±″.0314	±″.0194	30
Peter	±″.0115	±″.0062	11

Table VII presents the probable errors derived from the solution. Under the heading Obs. p. e. are given the means of the probable errors as published by the author. These were grouped according to the size of the probable error and compared with the computed results. It is evident that for the stronger authorities the observed and computed probable errors are very nearly alike. The Mt. Wilson trigonometrical parallaxes appear to have a considerably smaller computed error than that assigned to the observations, but this is largely due to the fact that they are, in the main, solely compared with the Mt. Wilson spectroscopic parallaxes in forming the present system, and as the latter were largely based on the former in forming the spectroscopic system for small proper-motion stars, it is natural that the agreement between the two should greatly reduce the probable error computed for the Mt. Wilson trigonometrical parallaxes. It has therefore been assumed that the real probable errors for this authority are represented by the observed probable errors. It was likewise assumed that for Yerkes, Allegheny and McCormick the published probable errors are the true probable errors.

The computed probable errors for Sproul indicate a slightly larger value than that assigned to the observations. It seemed advisable, therefore, to reduce the weight.

The Russell parallaxes indicated no change in the size of the computed probable error with increase in the observed probable error and therefore a uniform weight has been assigned to all.

The computed probable errors for the Yale parallaxes determined by Chase are very much smaller than those assigned by Chase, especially for the larger observed probable errors. In weighting the Chase parallaxes it has, therefore, been assumed that the observed probable errors represent the true prob-

Table VIII — Table of Weights

	±″.004	±″.005	±″.006	±″.007	±″.008	±″.009	±″.010	±″.011	±″.012	±″.013	±″.014	±″.015	±″.016	±″.017	±″.018	±″.019	±″.020	±″.025	±″.030	±″.040	±″.050	±″.060	±″.070
Yerkes	1.0	4.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.59	0.51	0.44	0.39	0.35	0.31	0.28	0.25	0.16		. .	. .	. .	
Allegheny	4.0	1.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.79	0.51								.	. .	. .	. .	
McCormick	1.0	1.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.59	0.51	0.44	0.39							. .	.		
Mt. Wilson (Trig.)	1.0	1.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.79	0.51	0.41	. .								.	. .	
Sproul	1.0	2.7	1.9	1.4	1.0	0.83	0.66	0.57	0.46	0.39	0.34	0.30	0.26	0.23	0.21	0.18						.	
Russell		.	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	
Yale (Chase)	1.0	1.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.59	0.51	0.44	0.59	0.35	0.31	0.28	0.25	0.23	0.21	0.12	0.07	0.05	0.04
Yale (Smith)						0.57	0.46	0.38	0.32	0.27	0.24	0.21	0.18	0.16	0.14	0.13	0.11	0.07	0.05	0.03	. .	. .	. . .
Washburn I												.				.	0.18	0.12	0.08	0.05	0.03	0.02	0.01
Washburn II						.					. . .	.	0.30	0.26	0.24	0.21	0.19	0.12	0.08	0.05	0.03	. .	.
Peter	1.0	1.0	2.8	2.0	1.6	1.2	1.0	0.83	0.69	0.59	0.51	0.44	0.39	0.35	0.31	0.28	0.25	0.16	. . .	. . .	.		
Jost			.								.	.	. .	0.35	0.31	0.28	0.25	0.16	0.11	0.06	0.04	. .	. . .

able errors to $\pm''.020$. From this point on a considerably heavier weighting was adopted than that indicated by the observed probable error. For the Yale parallaxes observed by SMITH the weighting indicated by the observed probable errors was reduced about one-half.

The weights of the two series of Washburn were reduced by the amount indicated by the comparison of observed with computed probable errors.

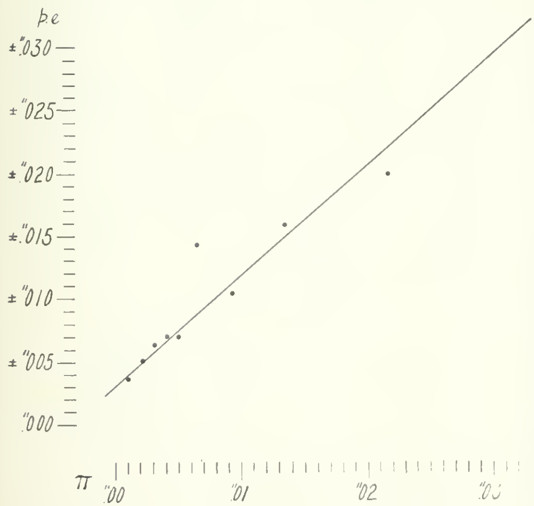
The adopted weights are to be found in Table VIII.

The weights of the Mt. Wilson spectroscopic parallaxes were determined by grouping the residuals from the second approximation according to the size of the observed parallaxes. It was first noted that there was no systematic tendency of the mean of the residuals taken according to sign, such as was manifested in the first approximation, clearly indicating that the previous result was due entirely to the faulty weighting. Table IX shows the computed values of the probable errors.

TABLE IX

No. **	π	p. e.	No. ***	π	p. e.
41	''.0103	±''.0037	28	''.0648	±''.0142
25	.0214	.0051	31	.0921	.0104
29	.0305	.0063	19	.1337	.0159
29	.0409	.0070	17	.214	.0200
31	.0495	.0070			

The observed results were plotted with the parallax as the abscissa, and the probable error as the ordinate. The accompanying diagram represents the computed probable errors and the line represented by the formula



$$\text{p. e.} = \pm(''.0031 + ''.0833\pi)$$

This leads to the following table of weights, the maximum weight assigned being 4.0 corresponding to a probable error of $\pm''.005$, though the indicated weight at parallax ''.00 is 10.4, and that at parallax ''.01 equals 6.2.

TABLE X

Mt. Wilson (Spec.) Wts.

π	wt.	π	wt	π	wt.
''.00	4.0	''.11	.61	''.21	.21
.01	4.0	.12	.53	.22	.20
.02	4.0	.13	.47	.23	.18
.03	3.0	.14	.42	.24	.17
.04	2.3	.15	.38	.25	.16
.05	1.8	.16	.34	.30	.11
.06	1.4	.17	.31	.35	.09
.07	1.2	.18	.28	.40	.07
.08	1.0	.19	.25	.45	.06
.09	.83	.20	.23	.50	.05
.10	.71				

The relation between the probable error and the number of plates taken is illustrated in Table XI.

TABLE XI

No. plates	Mean π	p. e.	No. ***	p.e. from formula
1	''.077	±''.0065	9	±''.0099
2	.049	.0074	51	± .0074
3	.065	.0093	137	± .0088
>3	.090	.0100	51	± .0110

The last column gives the probable errors corresponding to the mean parallaxes of the second column to afford a basis of comparison compensating for the varying size of mean parallax. It is evident that the employment of more than one plate does not increase the accuracy of the derived parallax. This is important as it greatly reduces the necessary amount of labor. Two plates, the one to serve as a check, will suffice for spectroscopic parallax work. For a less powerful instrument than the 60-inch reflector of the Mt. Wilson Observatory it might be advisable to test the dependence of the size of the probable errors upon the number of plates taken.

Finally the Mt. Wilson spectroscopic parallaxes were tested for the effect of giant and dwarf classification. Table XII shows the results. The residuals from the second approximation were grouped in their respective classes, and means by weight taken.

Table XII

Giants			Dwarfs	
p. e.	Mean of resid.	Type	Mean of resid.	p. e.
±″.0018	−″.0030	*M*	−″.0040	±″.0036
.0010	− .0006	*K*	+ .0020	.0015
.0010	− .0003	*G*	+ .0025	.0017
.0018	− .0032	*F*	+ .0006	.0014

While there seems to be a grouping of minus corrections for the giants, and plus for the dwarfs, they are opposite in sign from those obtained from the first approximation, and, judging by the probable errors of the means, may be entirely fictitious. It is certain that the correction would be small.

The results obtained in this treatment of the parallaxes will be used in the succeeding articles dealing with the luminosities and real motions of the stars.

I wish to express my grateful and hearty appreciation to Messrs. Schlesinger, Mitchell, Frost, and Miller for their generous coöperation. The additional unpublished parallaxes which they transmitted have more than doubled the weight of the system.

My thanks are due to Mr. Raymond who carried out the laborious steps of the last approximation.

Summary

1. An attempt has been made to harmonize the observed parallaxes.

2. The evidence brought forth indicates the possible existence of terms in α and 2α in all parallax observations with the exception of those determined spectroscopically.

3. Where the modern photographic methods of parallax observations have been adopted, the probable errors assigned by the observers represent the true probable errors of the parallaxes. For systems antedating the more modern methods various conventions have to be made.

4. The probable error of the Mt. Wilson spectroscopic parallaxes reaches its minimum value of $\pm''.0031$ at zero parallax and increases according to the formula p. e. $= \pm(''.0031 + ''.0833\pi)$. Therefore, for the great majority of the stars, the spectroscopic method will yield more accurate data than those obtained by other known methods.

It is to be noted, however, that for stars whose mean parallax is ″.0034 the probable error is of the same order as the parallax. According to Kapteyn (*Groningen Publications*, No. 29) this mean parallax corresponds to a star of 10 magnitude visual. The Mt. Wilson spectroscopic results would therefore seem to be incapable of furnishing reliable data on mean parallactic motions for stars much fainter than 10 magnitude.

5. The accumulation of plates for the determination of spectroscopic parallaxes at Mt. Wilson would seem unnecessary as the probable error of a parallax seems to be independent of the number of plates utilized, a fact which points to inaccuracies in the system as being mainly responsible for the errors found. In comparison, the accidental errors of plate measurement must be small.

6. While a certain systematic tendency is evidenced by the mean residuals of the spectroscopic parallaxes, grouped according to spectral sequence from *M* gaint to *M* dwarf, the probable error of the determination is sufficient to cast considerable doubt upon its reality. It is certain that the Mt. Wilson system is very closely adjusted among the spectral classes.

List of Parallax Series for Which Systematic Corrections Could Be Determined

Mt. Wilson (Sp.)	*Ap. J.* 46, 313 (Dec. 1917).
Mt. Wilson (Trig.)	*A.J.* 723 (1917). *A.J.* 755 (1919).
Allegheny	*Pub. Alleg. Obs.* IV, 1. *A.J.* 765 (1920) and manuscript.
Leander McCormick	*Pop. Ast.* XXV, 23 (1917) and manuscript.
Yerkes	*Pub. Yerkes Obs.* IV, 1 (1917). *A.J.* 752 (1919) and manuscript.
Sproul	*Sproul Obs. Pub.* IV (1918) and manuscript.
Yale (Chase) (Smith)	*Trans. Ast. Obs. Yale.* II, 387. (1912)
Russell	*A.J.* 618-9 (1910).
Washburn I	*Pub. Washburn Obs.* XI (1902).
Washburn II	*A.J.* 631 (1912).
Jost	*Heidelberg Veröff.* IV (1906).
Peter	*Abh. d. Math. Phys. Classe d. k-sächs. Gesell d. Wiss.* XXII 239 (1895), XXIV 179 (1898), XXVII 591 (1902), XXX 471 (1908)

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MEASURES OF 100 DOUBLE STARS,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER MCCORMICK OBSERVATORY.

By CHAS. P. OLIVIER.

The present paper forms a continuation of the series by the writer which have appeared from time to time since 1906. As in the other recent papers, the measures are largely made up of the discoveries of AITKEN and JONCKHEERE, there being 25 of the former and 36 of the latter. Of the ESPIN pairs 14 were also measured.

The right ascensions and declinations of the stars are given for 1920. When possible these co-ordinates and the designations were taken from JONCKHEERE's "Catalogue of Double Stars," otherwise from BURNHAM's "General Catalogue." When from the former the catalogue number is bracketed [ ], when from the latter unbracketed. No changes of methods in the observing have been introduced. Powers of 336, 560, 600, 850, 1100 and 1500 were employed. Probably power 600 was used most. The majority of the measures were made when the seeing was good. The magnitudes given are estimates made at the telescope.

It has been the writer's policy in this paper, and will continue to be for some time, to measure as many of the JONCKHEERE pairs as possible. Attention is also particularly paid to all objects of interest south of the equator, as these generally are more in need of measures. Of the 100 doubles in this paper, 25 have a southern declination. As to distances, 16 are less than 1″ in separation, and 36 between 1″ and 2″. All except *Sirius* are under 5″.

Following the list of measures is a table containing new doubles found by the writer. Of these OL 66 to OL 77 inclusive were found on plates taken for the determination of stellar parallaxes. Only the final results of these are given as the details form part of an extensive paper on doubles measured on photographic plates, now in press. The pairs OL 78 to OL 85 inclusive were found at the telescope, but as only two of them have been measured on more than one night merely the approximate results are given here for the others.

J 633 [**70**] 9.6 — 11.9

R.A. $0^h\,25^m\,48^s$ Decl. $+4°\,19'$

1917.713	317.6	2.50
1917.880	312.6	2.75
1917.796	315.1	2.62

h 3447 **836** Δm. 0.5

R.A. $1^h\,32^m\,25^s$ Decl. $-30°\,19'$

1916.821	98.2	1.62
1916.908	98.4	....
1916.864	98.3	1.62

Much change in distance, some in angle.

A 445 A—B **1182** 9 — 11.2

R.A. $2^h\,12^m\,24^s$ Decl. $-5°\,38'$

1916.908	185.8	1.97
1917.880	185.9	2.18
1917.394	185.8	2.08
	A — C	
1916.908	134.9	68.35

A 659 **12892** Δm. 0.1

R.A. $2^h\,24^m\,23^s$ Decl. $+40°\,53'$

1916.861	89.6	0.87
1919.917	89.0	0.90
1918.389	89.3	0.88

OL 9 [**118**] 9.3 — 10.7

R.A. $2^h\,39^m\,55^s$ Decl. $-1°\,56'$

1917.713	333.1	2.50
1917.880	228.0	2.67
1919.917	330.8	2.57
1918.503	330.6	2.61

J 711 [**729**] 9.8 — 10.2

R.A. $4^h\,49^m\,37^s$ Decl. $-3°\,10'$

1917.858	171.7x	2.63
1919.917	169.9	2.90
1918.888	170.8	2.76

J 712 [**733**] 9.0 — 9.7

R.A. $1^h 50^m 54^s$ Decl. $-3° 10'$

1917.858	168.7	2.19
1919.917	166.7	2.21
1918.888	167.7	2.00

J 325 [**830**] 9.3 — 11.3

R.A. $5^h 14^m 23^s$ Decl. $-9° 11'$

1916.919	180.9	1.68
1916.921	182.2	2.03
1916.052	174.3	1.97
1919.917	178.9	1.98
1917.702	179.1	1.92

OL 56 9.8 — 10.9

R.A. $5^h 21^m$ Decl. $-0° 40'$

1917.844	116.2	2.39
1919.898	106.5	2.32
1920.081	108.5	2.30
1919.274	110.4	2.34

J 714 [**957**] 9.5 — 10.5

R.A. $5^h 39^m 7^s$ Decl. $-4° 56'$

1917.841	128.6	3.35
1919.898	135.0	3.51
1919.917	128.9	3.42
1919.220	130.8	3.43

J 336 AC [**1107**] Δm. 0.0

R.A. $6^h 3^m 0^s$ Decl. $+10° 16'$

1919.898	148.8	2.74
1919.925	141.9	2.52
1919.912	146.8	2.63

J 964 [**1108**] 9.3 — 10.0

R.A. $6^h 3^m 6^s$ Decl. $+9° 58'$

1919.898	286.6	1.93
1919.925	288.1	1.89
1919.912	287.4	1.91

J 716 [**1136**] 9.7 — 9.9

R.A. $6^h 8^m 37^s$ Decl. $+11° 49'$

1917.855	70.0	2.46
1917.970	76.9	2.40
1918.184	73.5	2.42
1918.003	73.5	2.43

Sirius **3596**

R.A. $6^h 42^m 11^s$ Decl. $-16° 39'$

1917.052	73.7	10.47
1917.741	71.2	10.27
1917.844	71.6	11.26
1917.546	72.2	10.67
1918.175	71.9	10.69
1918.184	71.4	10.94
1918.214	70.5	11.03
1918.191	71.3	10.89
1920.089	67.4	10.80
1920.113	66.8	10.42
1920.101	67.1	10.61

J 702 [**1195**] 9.1 — 10.5

R.A. $7^h 5^m 30^s$ Decl. $+5° 34'$

1917.072	270.0	2.72
1917.105	268.4	3.17
1919.898	269.7	2.69
1918.025	269.4	2.83

ROE 25 [**1523**] 9.3 — 10.3

R.A. $7^h 10^m 52^s$ Decl. $+12° 29'$

1919.898	7.1	2.85
1919.925	1.6	3.00
1920.081	7.6	2.92
1919.968	5.4	2.92

J 42 [**1521**] Δm. 0.2

R.A. $7^h 11^m 1^s$ Decl. $+8° 2'$

1919.898	77.1	2.17
1919.925	80.2	2.21
1919.912	78.8	2.19

J 43 [**1560**] 10.0 — 10.2

R.A. $7^h 19^m 32^s$ Decl. $+8° 25'$

1919.898	65.5	3.33
1919.925	67.9	....
1920.081	67.4	3.40
1919.968	66.9	3.36

J 1065 [**1601**] Δm. 0.1

R.A. $7^h 27^m 9^s$ Decl. $-3° 32'$

1919.971	331.1	2.59
1920.081	336.0	2.48
1920.026	333.6	2.54

J 370 [**1605**] Δm. 0.1

R.A. $7^h 27^m 12^s$ Decl. $-5° 59'$

1919.971	67.9	2.37
1920.081	65.8	2.36
1920.026	66.8	2.36

OL 78 9.8 — 10.5

R.A. $7^h 39^m$ Decl. $+11° 14'$

1918.156	278.4	1.20
1918.252	277.4	1.03
1918.204	277.9	1.12

OL 59 9.8 — 11.0

R.A. $7^h 44^m$ Decl. $+11° 16'$

1917.970	17.4	2.46
1919.898	16.2	2.61
1918.934	16.8	2.54

VAN 3 [**1839**] 8.6 — 8.8

R.A. $8^h 46^m 24^s$ Decl. $+8° 9'$

1917.855	91.6	2.19
1918.156	91.0	2.22
1918.006	91.3	2.20

J 77 [**1872**] 9.0 — 9.2

R.A. $9^h 0^m 45^s$ Decl. $+10° 49'$

1917.854	139.8	....
1917.969	139.3	1.02
1918.156	139.7	1.15
1917.993	139.6	1.08

J 424 [**1880**] 8.9 — 9.3

R.A. $9^h 5^m 36^s$ Decl. $+0° 32'$

1918.227	136.0	1.18
1918.256	136.8	1.18
1918.240	136.4	1.18

A 2754 [**1889**] 9.2 — 9.7

R.A. $9^h 11^m 5^s$ Decl. $+6° 21'$

1918.227	26.1	0.98
1918.252	24.3	0.93
1918.242	25.2	0.96

A 1761 [**1912**] 8.9 — 10.5

R.A. $9^h 19^m 25^s$ Decl. $-0° 46'$

1917.226	212.3	1.36
1917.970	207.0	1.40
1918.156	208.0	1.32
1917.784	209.1	1.36

A 1587 [**1917**] 9.2 — 11

R.A. $9^h 21^m 19^s$ Decl. $-8° 46'$

1918.227	104.3	0.79
1918.252	100.8	0.73
1918.240	102.6	0.76

β 591 **5111** Δm. 0.6

R.A. $9^h 25^m 34^s$ Decl. $-2° 16'$

1916.921	28.2	0.85
1918.227	29.4	0.75
1918.252	33.1	0.63
1917.850	30.2	0.74

J 746 [**1970**] 9.2 — 10.4

R.A. $9^h 50^m 50$ Decl. $-7° 34'$

1918.227	285.1	2.25
1918.252	287.7	1.99
1919.265	286.0	2.15
1918.581	286.3	2.13

J 426 [**1971**] 9.1 — 9.3

R.A. $9^h 52^m 0^s$ Decl. $+3° 51'$

1918.175	212.0	3.24
1918.252	212.4	3.21
1918.214	212.2	3.22

A 2564 [**1986**] 9.2 — 9.4

R.A. $10^h 4^m 3^s$ Decl. $+8° 26'$

1918.214	270.6	0.64
1918.252	269.1	0.63
1918.233	269.8	0.64

A 2764 [**1996**] Δm. 0.0

R.A. $10^h 8^m 59^s$ Decl $+5° 53'$

1918.214	362.0	1.57
1918.227	361.5	1.30
1918.152	359.1	. .
1919.265	362.1	1.39
1918.490	361.2	1.42

A 2566 [**1997**] 9.0 — 10.1

R.A. $10^h 10^m 43^s$ Decl. $+0° 34'$

1917.302	82.8	1.51
1918.156	85.6	1.65
1918.227	80.6	1.50
1917.795	83.0	1.55

Hu 1251 [**1998**] 9.2 — 9.4

R.A. $10^h 10^m 54$ Decl. $+12° 17'$

1918.214	38.9	0.74
1918.227	36.7	0.67
1918.220	37.8	0.70

J 1126 [**2003**] 9.4 — 9.4

R.A. $10^h 13^m 2^s$ Decl. $+12° 34'$

1918.214	310.0	2.08
1918.252	308.1	2.23
1918.233	309.0	2.16

J 717 [**2025**] 9.5 — 10.5

R.A. $10^h 25^m 0^s$ Decl. $-2° 57'$

1919.971	249.1	3.12
1920.048	249.3	3.11
1920.110	250.1	3.41
1920.010	249.6	3.21

J 79 [**2046**] 8.5 — 9.3

R.A. $10^h 35^m 17^s$ Decl. $+7° 51'$

1919.969	143.4	1.72
1918.214	144.4	1.71
1918.227	147.0	1.66
1918.137	144.9	1.70

A 2771 [**2057**] 9.1 — 9.2

R.A. $10^h 40^m 30^s$ Decl. $+5° 55'$

1918.214	25.8	0.78
1919.265	26.6	0.77
1918.740	26.2	0.78

A 2773 [**2069**] Δm. 1.5

R.A. $10^h 48^m 26^s$ Decl. $+5° 26'$

1919.971	25.2	1.18
1920.110	25.3	1.20
1920.040	25.2	1.19

J 1011 [**2097**] Δm. 0.2

R.A. $11^h 8^m 43^s$ Decl. $+5° 20'$

1919.971	69.6	2.94
1920.048	69.0	2.83
1919.010	69.3	2.88

β 26 **5766** Δm. 2.2

R.A. $11^h 19^m 44^s$ Decl. $-9° 59'$

1919.971	67.2	2.79
1920.110	66.6	2.73
1920.040	66.9	2.76

β 601 **5796** 8.5 — 8.9

R.A. $11^h 25^m 21^s$ Decl. $-16° 54'$

1915.040	213.5	0.93
1919.298	211.7	0.93
1917.169	212.6	0.93

J 87 [**2133**] 8.2 — 10.9

R.A. $11^h 36^m 51^s$ Decl. $+5° 21'$

1918.227	137.3	1.69
1918.372	136.2	1.54
1918.300	136.8	1.62

β 457 **6002** Δm. 3.5

R.A. $11^h 57^m 20^s$ Decl. $-21° 5'$

1915.040	85.8	1.25
1919.265	88.8	1.04
1919.298	85.4	1.16
1917.868	86.7	1.15

β 920 **6091** 7.2 — 8.2

R.A. $12^h 11^m 40^s$ Decl. $-22° 54'$

1915.042	267.0	0.97
1919.298	272.9	1.01
1917.170	270.0	0.99

Confirms motion.

β 606 **6165** Δm. 1.5

R.A. $12^h 21^m 55^s$ Decl. $-14° 30'$

1915.042	93.6	1.11
1917.266	98.1	1.22
1919.298	96.8	0.97
1917.202	96.2	1.10

J 1022 [**2190**] 9.9 — 10.4

R.A. $12^h 24^m 29^s$ Decl. $+4° 58'$

1918.227	222.4	2.25
1918.351	219.9	2.51
1918.372	223.5	2.44
1919.227	224.1	2.47
1918.544	222.5	2.42

J 431 [**2191**] 9.4 — 9.8

R.A. $12^h 25^m 27^s$ Decl. $-0° 36'$

1919.298	272.1	2.44
1919.303	270.3	2.38
1919.300	271.2	2.41

A 2780 [2193] 9.4 — 9.5

R.A. 12h 26m 2s Decl. −6° 27′

1919.227	214.0	0.67
1919.265	203.4	....
1919.298	205.6	0.65
1919.303	204.0	....
1919.273	206.8	0.66

A.G. 178 **6191** Δm. 0.2

R.A. 12h 27m 0s Decl. +2° 33′

1918.351	292.4	1.33
1920.110	287.4	1.40
1919.230	289.9	1.36

A 1599 [2197] 9.5 — 9.5

R.A. 12h 27m 59s Decl. +4° 20′

1918.227	154.4	0.39
1918.971	149.6	0.41
1918.599	152.0	0.40

A 1603 [2209] Δm. 3±

R.A. 12h 39m 55s Decl. +4° 22′

1919.971	142.6	1.62
1920.110	141.0	1.46
1920.040	141.8	1.54

J 432 [2211] Δm. 0.4

R.A. 12h 41m 17s Decl. +4° 58′

1918.227	266.0	1.00
1918.372	265.6	0.85
1919.227	262.8	0.98
1918.608	264.8	0.94

E 730 [2213] 9.0 — 11.7

R.A. 12h 45m 30s Decl. +51° 21′

1919.254	62.3	3.18
1919.298	66.9	3.14
1919.276	64.6	3.16

E 439 [2214] 8.8 — 9.4

R.A. 12h 47m 34s Decl. +27° 40′

1919.254	64.6	2.15
1919.298	64.1	2.10
1919.276	61.4	2.12

J 433 [2220] 9.2 — 9.7

R.A. 12h 55m 29s Decl. −0° 15′

1918.351	155.8	3.70
1919.265	154.1	3.38
1919.260	154.2	3.23
1919.298	156.9	3.50
1919.044	155.2	3.45

A 1785 [2225] 9.0 — 10.4

R.A. 13h 1m 45s Decl. +9° 30′

1918.351	126.8x	1.72
1919.260	126.1	1.82
1919.265	125.3x	1.89
1918.959	126.1	1.81

J 434 [2229] Δm. 0.2

R.A. 13h 4m 24s Decl. −0° 26′

1919.971	327.0	3.48
1920.110	324.6	3.34
1920.040	325.8	3.41

A 2585 [2245] 8.6 — 9.0

R.A. 13h 14m 49s Decl. +0° 56′

1918.227	233.9	0.89
1918.351	235.9	0.81
1919.227	229.4	0.75
1918.602	233.1	0.82

J 436 [2256] 9.2 — 9.7

R.A. 13h 23m 45s Decl. +0° 12′

1918.450	344.0x	2.36
1919.260	342.5	2.61
1919.265	338.6	2.26
1918.992	341.7	2.41

Σ 1757 **6530** Δm. 0.6

R.A. 13h 30m 14s Decl. +0° 6′

1918.351	84.9x	3.11
1919.303	82.3	2.75
1920.110	84.7	2.76
1919.255	84.0	2.94

A 2491 [2273] 9 — 11

R.A. 13h 38m 40s Decl. +2° 59′

1918.227	124.8	0.60
1919.227	119.3	....
1919.298	123.0	0.67
1918.917	122.4	0.64

E 309 [2271] 9.2 — 10.0

R.A. 13h 40m 15s Decl. +31° 58′

1919.254	132.0	1.80
1919.298	135.7	2.01
1919.276	133.8	1.90

β 935*a* **6618** 6 — 7

R.A. 13h 41m 31s Decl. −12° 1′

1915.287	296.9	1.55
1919.303	298.9	1.72
1917.295	297.9	1.64

A 2492 [2279] 10 — 10.2

R.A. 13h 43m 42s Decl. +1° 44′

1918.227	213.9	0.68
1919.227	208.3	0.60
1919.298	206.8	0.61
1918.917	209.7	0.63

J 750 [2303] 9.3 — 9.8

R.A. 14h 8m 36s Decl. +26° 52′

1919.254	93.9	1.96
1920.110	92.2	2.01
1919.682	93.0	1.98

J 1122 [2324] 9.8 — 10.2

R.A. 14h 30m 33s Decl. +6° 1′

1918.227	271.5	1.45
1918.372	270.8	1.64
1918.300	271.2	1.54
1919.260	277.8	1.56
1919.265	277.4	1.33
1919.298	275.3	1.50
1919.274	276.8	1.46

E 311 [2334] 9 — 10

R.A. 14h 50m 3s Decl. +34° 46′

1919.254	287.1	3.96
1920.110	291.4	4.01
1919.682	289.2	3.98

E 211 = A 1364.

E 774 [2351] 9.2 — 9.3

R.A. 15h 5m 1s Decl. +51° 14′

1919.254	52.0	3.46
1920.110	49.8	3.29
1919.682	50.9	3.38

E 625 [**2368**] 9.3 — 9.9

R.A. $15^h\,18^m\,21^s$ Decl. $+44°\,36'$

1918.448	[243.6x] ?	1.89
1919.227	255.1	1.86
1919.265	251.9	1.98
1918.980	253.5	1.91

First angle seems wrongly recorded by 10°.

A 1632 [**2371**] 9.0 — 9.4

R.A. $15^h\,22^m\,38^s$ Decl. $+46°\,25'$

1918.448	49.2	1.81
1919.265	55.0	1.59
1920.110	53.0	1.79
1919.274	52.4	1.73

A 2231 [**2388**] 9 — 12.5

R.A. $15^h\,41^m\,55^s$ Decl. $+0°\,15'$

1916.474	26.0	1.69
1919.303	24.1	1.86
1917.888	25.0	1.73

E 742 [**2392**] Δm. 0.1

R.A. $15^h\,44^m\,52^s$ Decl. $+53°\,52'$

1918.448	262.2	3.15
1920.110	261.8	3.25
1919.279	262.0	3.20

Σ 2021 **7551** Δm. 0.1

R.A. $16^h\,9^m\,37^s$ Decl. $+13°\,45'$

1912.548	335.2	4.19
1917.080	337.3	3.77
1920.110	335.5	3.61
1916.579	336.0	3.86

A 2083 [**2415**] 9.2 — 9.3

R.A. $16^h\,11^m\,5^s$ Decl. $+16°\,13'$

1919.227	326.3	0.90
1919.298	323.4x	0.89
1919.262	324.8	0.90

E 632 [**2439**] 9.5 — 10.2

R.A. $16^h\,38^m\,46^s$ Decl. $+50°\,22'$

1918.450	103.8	2.19
1919.227	105.7	2.15
1918.838	104.8	2.17

E 969 [**2151**] 9.4 9.6

R.A. $16^h\,43^m\,59^s$ Decl. $+50°\,20'$

1918.450	236.8	2.19
1919.227	237.5	2.73
1918.838	237.2	2.61

E 1089 [**2152**] 9.2 — 9.2

R.A. $16^h\,44^m\,17^s$ Decl. $+18°\,7'$

1918.450	318.5	2.62
1919.227	321.4	2.52
1918.838	321.0	2.57

Distance increasing?

Hu 1278 [**2155**] 9.2 — 9.3

R.A. $16^h\,48^m\,36^s$ Decl. $+15°\,44'$

1919.227	346.6	1.31
1919.260	346.7	1.37
1919.244	346.6	1.34

Distance increasing?

A 1868 [**2158**] Δm. 0.2

R.A. $16^h\,50^m\,23^s$ Decl. $+40°\,53'$

1918.450	305.8	1.94
1920.110	303.5	1.91
1919.280	304.6	1.92

E 972 [**2463**] 9.7 — 10.2

R.A. $16^h\,53^m\,35^s$ Decl. $+51°\,48'$

1918.450	103.5	2.13
1920.110	100.8	2.31
1919.230	102.2	2.22

Hu 1279 [**2468**] 9.4 — 10.0

R.A. $16^h\,56^m\,3^s$ Decl. $+13°\,25'$

1918.450	155.0	1.49
1919.227	158.1	1.87
1919.260	158.0	1.77
1918.979	157.0	1.71

J 452 [**2196**] 9.4 — 10.5

R.A. $17^h\,17^m\,10^s$ Decl. $+15°\,28'$

1919.227	298.5	2.49
1919.260	296.8	2.61
1919.244	297.6	2.55

Hu 1287 [**2512**] 9.1 — 9.3

R.A. $17^h\,42^m\,2^s$ Decl. $+15°\,51'$

1919.260	73.3	2.05
1919.298	74.7	2.15
1919.279	74.0	2.10

J 753 [**2519**] 9.2 — 9.5

R.A. $17^h\,44^m\,38^s$ Decl. $+15°\,48'$

1919.260	275.5	1.91
1919.298	274.0	1.96
1919.279	274.8	1.94

OL 85 8 — 12

R.A. $17^h\,45^m$ Decl. $+24°\,51'$

1919.260	232.4	2.88
1919.298	233.4	3.09
1919.279	232.9	2.98

J 754 [**2550**] 9.0 — 9.4

R.A. $17^h\,45^m\,44^s$ Decl. $+24°\,53'$

1919.260	51.2	1.70
1919.298	55.1	1.85
1919.279	53.2	1.78

J 1220 [**2593**] 9.0 9.3

R.A. $18^h\,1^m\,52^s$ Decl. $+12°\,42'$

1919.260	128.8	1.53
1919.298	121.7	1.64
1919.303	129.1	1.59
1919.287	126.5	1.59

Σ 2289 **8398** Δm. 0.6

R.A. $18^h\,6^m\,34^s$ Decl. $+16°\,27'$

1919.260	225.5	1.24
1919.303	223.8	1.28
1919.282	224.6	1.26

Σ 2199 **8118**

R.A. $18^h\,14^m\,58^s$ Decl. $+55°\,48'$

1914.458	83.0	1.80
1916.678	81.8	1.55
1920.110	81.0	1.69
1917.082	81.9	1.68

Perrine 8190 8.9 — 9.8

R.A. $18^h 16^m 4$ Decl. $+14° 0'$

1919.227	3.0	2.95
1919.303	4.2	3.12
1919.255	3.6	3.04

A 1648 [2896] 9.1 — 9.2

R.A. $19^h 23^m 24^s$ Decl. $+15° 56'$

1917.715	4.9	0.99
1919.500	3.9x	1.03
1918.608	4.4	1.01

A 1486 [3872] 9.1 — 9.9

R.A. $23^h 24^m 48^s$ Decl. $+54° 58'$

1917.893	256.2	0.63
1919.917	259.3	0.81
1918.905	257.8	0.72

J 752 [2631] 9.3 — 10.4

R.A. $18^h 21^m 32^s$ Decl. $+16° 44'$

1919.260	276.0	3.01
1919.303	279.7	2.86
1919.282	277.8	2.94

A 2295 [3772] 9.4 — 11.8

R.A. $22^h 41^m 1^s$ Decl. $+2° 10'$

1916.682	69.6	1.35
1916.721	76.6	1.13
1917.877	77.4	1.08
1917.093	74.5	1.19

E 1124 [3915] 9.2 — 9.3

R.A. $23^h 46^m 17^s$ Decl. $+50° 48'$

1917.893	246.5	2.81
1919.917	247.2	2.62
1918.905	246.8	2.72

J 1174 [2843] 9.5 — 9.9

R.A. $19^h 11^m 37^s$ Decl. $+18° 2'$

1917.781	300.1	2.97
1919.500	298.2	3.04
1918.640	299.2	3.00

E 1189 [3868] 9.8 — 10.0

R.A. $23^h 23^m 42$ Decl. $+50° 12'$

1917.893	137.0	1.45
1919.917	136.6	1.49
1918.905	136.8	1.47

E 1476 [3919] 9.8 — 10.0

R.A. $23^h 47^m 45^s$ Decl. $+42° 38'$

1917.893	64.1	1.53
1919.917	62.4	1.42
1918.905	63.2	1.48

Star	R. A.	Decl.	P. A.	Δ	Magn.
	h m s	° ′	°	″	
OL 66	6 15 17	− 2 48	109.1	3.16	9.5 9.8
OL 67	6 18 10	+22 12	37.7	4.95	9.5 10
OL 68	7 48 1	−13 54	121.7	3.04	11 12
OL 69	8 12 38	−11 35	320.3	2.63	9 11
OL 70	14 30 49	−11 42	109.2	3.11	9.8 11.5
OL 71	19 42 15	+18 20	168.8	4.31	9.5 9.6
OL 72	19 43 11	+18 27	9.9	4.31	9.5 9.5
OL 73	20 9 32	+20 58	132.5	1.35	9.8 10.8
OL 74	20 21 7	+54 49	40.7	3.79	11 11.2
OL 75	20 26 1	+29 52	135.2	1.36	10 11.0
OL 76	21 26 20	−22 24	340 ±	2.5 ±	9.5 10
OL 77	23 59 23	+34 08	255.6	2.60	9 11
OL 78	7 39	+11 14	277.9	1.12	9.8 10.5
OL 79	7 26	− 1 59	204	1.9	9.5 10.3
OL 80	18 52	−19 55	140	3.2	9.5 11.5
OL 81	18 57	−13 20	330	2	10 12
OL 82	19 30	+18 07	242	1.2	9.8 12
OL 83	22 46	−23 37	243	3.8	8.8 14
OL 84	23 28	+50 43	144	1.6	9.5 9.6
OL 85	17 45	+24 51	232.9	2.98	8 12

University of Virginia,
Feb. 23, 1920.

NOTE.

The curators of the Bachiene Institution of the Leyden University propose the following prize-subject.

Required: to derive from the astronomical (angular) proper-motions of the stars belonging to the second and third spectral types (Harvard Classifications F, G, K, M) the frequency of a component of the linear peculiar velocity as a function of its amount.

Explanation. It is supposed that the theory of the star-streams, in the form given to that theory by Eddington, is accepted. Peculiar velocity then means the velocity freed both from the *Sun's* motion and from the stream motion. It is permissible to admit that the motions, corrected in this way, have no longer a preference for any particular direction, and that, consequently, the required frequency law will be the same for all components.

The same problem has been treated by means of the radial velocities in the "Proceedings of the National Academy of Sciences" (Washington) Vol. 1, pp. 17-19. The treatment has been given more elaborately and

corrected in "Publications of the Astronomical Laboratory" at Groningen No. 30, second appendix.

As to the required treatment by means of the astronomical (angular) proper-motions, a beginning has been made by SCHWARZSCHILD in *Astronomische Nachrichten*, No. 4557. In this treatment, however, the *Sun's* motion has been taken into consideration only in a very rough way, while the stream motion has been neglected.

A separate treatment of the spectra *F*, *G*, *K*, *M*, if possible, will be preferable. Still solutions in which these classifications are treated together or in two or three groups may truly compete for the prize. A very approximate freedom from both the *Sun's* and the stream motion may take the place of complete freedom, if it appears that, with existing material, the latter is not attainable.

The work has to be based on extensive material of very accurate proper-motions (*e. g.* on Boss's *Catalogue*.)

The competition is open to everyone. The paper containing the solutions has to be sent before March 1, 1921, to the secretary of the curators, MR. H. KRABBE, Leyden, Witte Singel 28. It must be typewritten in Dutch, French, German or English, with the address of the author enclosed in a sealed envelope on which is written the same nom de plume with which the paper itself must be signed. The author to whom the prize is awarded receives a calligraphed certificate in parchment, together with a sum of money amounting to at least five hundred guilders.

The paper remains the property of the author.

THE CURATORS OF THE BACHIENE INSTITUTION,

J. OPPENHEIM, *President*.
H. KRABBE, *Secretary*.

Leyden, February 1920.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL OF THE CINCINNATI OBSERVATORY,

BY EVERETT I. YOWELL.

Date	G. M. T.	☌ − ★ Δα	☌ − ★ Δδ	No. Comp.	☌ App α	☌ App. δ	log pΔ α	log pΔ δ	★
			Comet *b* 1919 (BRORSEN-METCALF)						
1919	h m s	m s	′ ″		h m				
Aug. 28	15 41 58	+2 12.97	. . . . . .	12 , 0	22 22 27.13	. . . . .	9.484*n*		1
28	15 41 58	. . . .	+ 2 49.1	0 , 5	. . . . .	+45 00 26.1	. . .	9.540*n*	2
Sept. 1	15 48 43	−0 46.66	+ 3 34.7	12 , 5	21 38 58.25	+60 24 09.8	9.273*n*	0.376*n*	3
2	15 40 17	+0 19.41	+ 6 28.5	12 , 6	21 18 05.37	+64 38 36.0	9.150*n*	0.587*n*	5
3	16 18 01	−0 12.02	− 0 46.4	16 , 6	20 47 29.68	+68 49 56.4	9.361	0.762*n*	6
			Comet *c* 1919 (BORRELLY-METCALF)						
Aug. 28	14 44 58	−0 44.75	− 5 31.7	12 , 5	14 12 37.58	+24 46 19.0	9.694	0.654	7
Sept. 1	14 28 40	−0 11.63	+ 8 00.9	11 , 5	14 19 14.49	+23 07 56.9	9.686	0.656	8
13	13 47 06	−0 12.27	− 2 08.8	18 , 6	14 40 57.19	+17 55 08.4	9.664	0.671	9
14	13 38 22	+1 24.10	+ 9 49.1	18 , 5	14 42 53.64	+17 28 12.3	9.659	0.667	10
15	13 31 38	+2 42.50	− 7 24.8	9 , 2	14 44 51.10	+17 00 53.4	9.655	0.666	11
16	13 15 39	+2 10.67	+ 4 38.8	12 , 4	14 46 18.87	+16 33 30.9	9.641	0.658	12
24	13 20 45	−1 29.11	− 1 08.9	17 , 5	15 03 26.62	+12 46 43.4	9.650	0.693	13
25	13 32 45	+0 39.85	− 5 43.6	11 , 5	15 05 38.06	+12 17 29.5	9.656	0.703	15
26	13 14 48	−0 12.08	+ 1 50.4	12 , 4	15 07 47.72	+11 48 32.5	9.647	0.695	16
			Comet *d* 1919 (FINLAY-SASAKI)						
Nov. 22	14 47 09	−1 03.56	−14 12.2	12 , 6	0 15 00.77	+ 2 21 17.6	9.199	0.721	17
24	14 39 26	+0 45.76	− 4 04.7	12 , 6	0 28 29.77	+ 4 20 21.3	9.124	0.700	18

Sept. 3. Hazy, comet difficult.

Comparison Stars.

Mean places for 1919.0 and reductions to apparent place.

★	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	22 20 09.97	+44 53 22.2	+4.49		*A. G. Bonn* 16675 pr. (mean −s.30).
2	22 22	+44 57 12.9	.....	+24.1	Compared with *1 : Δδ = +50″.7.
3	21 39 40.30	+60 20 09.4	+4.61	+25.7	Compared with *4 : Δα = +1m 27s.49, Δδ = −4′ 00″.8.
4	21 38 12.81	+60 24 10.2	....	....	*A.G. Hels.* 12426.
5	21 17 41.45	+64 31 41.0	+4.48	+26.5	Boss *P. G. C.* 5488 (6 *Cephei*).
6	20 47 37.58	+68 50 15.6	+4.12	+27.2	*A.G. Chris.* 3238.
7	14 13 20.48	+24 52 21.0	+1.85	− 0.3	½ (*A.G. Ber. B* 5032 + *A.G. Cambr. E* 6780).
8	14 19 24.27	+22 59 56.3	+1.85	− 0.3	*A.G. Ber. B* 5060.
9	14 41 07.88	+17 57 17.5	+1.88	− 0.3	*A.G. Ber. A* 5320.
10	14 41 27.65	+17 18 23.7	+1.89	− 0.5	Boss *P. G. C.* 3770 (*o Bootis*).
11	14 42 06.71	+17 08 18.7	+1.89	− 0.5	*A.G. Ber. A* 5331.
12	14 44 36.30	+16 28 52.7	+1.90	− 0.6	*A.G. Ber. A* 5349.
13	15 04 53.80	+12 47 52.5	+1.96	− 0.2	*A.G. Lpz.* 5315.
14	15 04 26.18	+12 32 02.0	.....	...	*A.G. Lpz.* 5312.
15	15 04 56.26	+12 23 13.2	+1.95	− 0.1	Compared with *14 : Δα = +30s.08, Δδ = −8′ 48″.8.
16	15 07 57.84	+11 46 42.2	+1.96	− 0.1	*A.G. Lpz.* 5328.
17	0 16 00.07	+ 2 35 02.4	+4.26	+27.4	*A.G. Alb.* 55.
18	0 27 39.68	+ 4 23 58.6	+4.33	+27.4	*A.G. Alb.* 98.

ON THE POSITIONS OF *NEPTUNE* AND *URANUS*.

By H. R. MORGAN.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

The observations of *Neptune* and *Uranus* taken with the 9-inch Transit Circle of Naval Observatory since 1903, have been preliminarily reduced, on a uniform basis, as referred to NEWCOMB's system of star places. The mean correction to the *American Ephemeris* has been formed, as given below, for oppositions near which observations were taken. The quantities represent the corrections to NEWCOMB's new tables of *Neptune* and *Uranus*, which have been used in the *Ephemeris* since 1903 and 1904 respectively.

Neptune

Mean Date	No. Obsn's	Corr. to *Am. Eph.* Δα	Δδ
		s	″
1903.98	15	−0.02	−0.5
1905.07	15	−0.03	−0.5
1906.08	14	−0.02	−0.3
1908.03	15	−0.04	−0.5
1909.02	16	−0.06	−0.4
1910.04	15	−0.06	−0.2
1911.02	15	−0.04	−0.2
1912.12	8	−0.05	+0.3
1913.05	15	−0.06	−0.4
1914.07	12	−0.07	0.0
1915.07	13	−0.07	−0.2
1916.08	12	−0.05	−0.1
1917.05	15	−0.06	+0.2
1918.14	15	−0.08	−0.2
1920.08	14	−0.09	−0.1

Uranus

Mean Date	No. Obsn's	Corr. to *Am. Eph.* Δα	Δδ
		s	″
1904.54	15	+0.09	0.0
1905.51	7	+0.12	−0.1
1906.56	11	+0.08	−0.4
1908.53	17	+0.16	−0.2
1909.53	13	+0.15	−0.1
1910.53	15	+0.21	+0.6
1912.58	15	+0.18	+0.5
1914.60	16	+0.22	+0.4
1916.70	10	+0.16	+0.3
1919.66	11	+0.15	+0.2

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OBSERVATIONS DE COMÈTES ET PLANÈTES,

FAITES À L'OBSERVATOIRE DE BESANÇON, ÉQUATORIAL COUDÉ DE $0^{m}.33$ D'OUVERTURE,

PAR M P. CHOFARDET.

Dates	T. m. Besançon	⅃ A.R.	⅃ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		*
Comète Borrelly (1905 II)											
1918	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Oct. 9	13 2 6	+1 6.67	− 1 9.4	12, 9	5 53 42.64	9.521n	97 37 14.5	0.837n	+3.57	− 9.2	1
10	13 5 3	−1 3.53	− 7 40.7	12, 9	5 55 33.54	9.514n	97 20 30.3	0.838n	+3.58	− 8.7	2
Nov. 23	9 13 16	−2 2.86	+ 3 3.7	9, 12	6 56 43.35	9.626n	70 42 37.1	0.770n	+5.28	+ 9.5	3
30	9 19 52	−3 7.80	+ 0 12.2	9, 12	7 0 47.18	9.641n	63 6 29.0	0.709n	+5.75	+12.3	4
Déc. 6	9 31 30	+1 33.72	+ 5 20.9	12, 12	7 2 16.21	9.650n	56 13 32.6	0.614n	+6.29	+13.3	5
1919											
Janv. 6	6 9 33	−1 53.65	− 5 23.6	9, 9	6 40 34.80	9.908n	29 21 21.4	0.395n	+4.66	+ 4.6	6
7	6 32 9	−3 40.77	− 5 16.8	9, 12	6 39 27.48	9.903n	28 53 12.0	0.254n	+4.67	+ 4.4	7
20	6 33 55	−4 43.53	− 0 27.6	12, 16	6 28 23.24	9.912n	24 55 58.6	8.595	+5.31	+ 0.1	8
21	6 14 59	+1 40.42	+ 6 30.2	9, 12	6 27 56.00	9.929n	24 45 59.6	9.386n	+5.33	− 0.9	9
22	6 17 0	+1 18.42	− 2 59.1	12, 12	6 27 33.99	9.926n	24 36 30.0	8.959n	+5.32	− 1.2	9
Févr. 4	9 43 40	−1 5.49	− 2 6.1	12, 12	6 30 16.29	8.602	23 43 56.1	0.460	+5.32	− 3.6	10
Comète périodique Kopff (1919 *a*)											
Août 16	9 35 18	+1 8.98	+ 5 34.4	9, 6	19 27 31.56	8.432n	98 26 39.4	0.860n	+4.20	−16.2	11
18	9 49 22	+1 44.40	+ 1 26.1	12, 12	19 28 6.97	7.975	98 22 31.0	0.859n	+4.19	−16.3	11
19	10 1 51	+2 4.69	− 0 26.0	9, 12	19 28 27.26	8.589	98 20 38.9	0.859n	+4.19	−16.3	11
20	10 43 19	−2 10.13	+ 2 26.7	9, 12	19 28 49.75	9.067	98 18 54.2	0.857n	+4.19	−16.7	12
22	9 50 50	−1 21.20	− 0 35.3	12, 9	19 29 38.67	8.581	98 15 52.1	0.859n	+4.18	−16.8	12
23	9 55 7	−0 53.75	− 1 55.2	12, 9	19 30 6.11	8.715	98 14 32.0	0.860n	+4.17	−17.0	12
25	9 44 6	+0 14.04	− 1 10.6	9, 6	19 31 6.41	8.650	98 12 7.3	0.861n	+4.15	−17.0	13
27	9 37 36	+1 21.76	− 3 14.4	9, 6	19 32 14.12	8.653	98 10 3.5	0.861n	+4.14	−17.0	13
28	9 42 32	+1 58.05	− 4 10.8	6, 3	19 32 50.40	8.774	98 9 7.0	0.860n	+4.13	−17.1	13
30	9 31 31	−1 37.57	− 1 55.6	12, 6	19 34 8 46	8.714	98 7 26.6	0.860n	+4.13	−17.4	14
Sept. 22	9 35 1	+1 38.26	− 0 4.1	9, 6	19 56 30.93	9.238	97 55 24.6	0.855n	+3.90	−19.4	15
25	8 35 5	+0 14.50	− 4 14 7	12, 9	20 0 13.26	8.936	97 53 20.2	0.857n	+3.88	−19.8	16
Comète Metcalf (1919 *b*)											
Août 23	9 18 6.4	−1 25.33	+ 0 32.8	12, 9	22 44 36.78	9.552n	59 42 59.6	0.560n	+4.32	−23.4	17
23	10 22 20.9	−1 4.53	− 0 7.8	12, 9	22 44 29.31	9.417n	59 37 0.5	0.484n	+4.32	−23.4	18
25	11 16 26.0	−0 43.40	− 4 29.8	12, 9	22 38 6.16	9.162n	54 39 41.1	0.288n	+4.38	−23.6	19
27	10 26 37.4	−1 7.24	+ 1 3.6	12, 9	22 29 35.70	9.360n	49 1 1.8	0.120n	+4.46	−23.8	20

Dates	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		*
					Comète Metcalf-Borrelly (1919 c)						
1919	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Août 25	9 14 52	+1 26.31	+ 8 8.7	12 , 9	14 7 29.26	9.641	63 54 26.6	0.725*n*	+1.84	+ 0.3	21
27	9 4 15	−0 39 13	+ 5 52.2	12 , 9	14 10 37.20	9.636	64 42 35.7	0.724*n*	+1.85	+ 0.2	22
28	9 13 1	−1 8.40	− 0 36.1	9 , 6	14 12 13.99	9.638	65 7 3.0	0.736*n*	+1.86	+ 0.2	23
30	9 1 14	+1 9.01	− 4 56.5	9 , 6	14 15 28.68	9.635	65 56 5.9	0.737*n*	+1.85	+ 0.4	24
Sept. 22	8 59 52	−0 8.47	− 3 2.4	3 , 3	14 58 44.59	9.616	76 9 53.8	0.799*n*	+1.94	+ 0.3	25
25	7 59 6	+0 7.60	− 1 28.6	12 , 9	15 5 5.66	9.602	77 35 18.4	0.780*n*	+1.97	+ 0.2	26
30	7 21 4	−2 44.22	− 4 30.7	9 , 12	15 16 11.40	9.582	80 2 12.6	0.779*n*	+2.01	− 0.2	27
Oct. 11	6 42 1	+1 3.16	− 3 25.0	6 , 3	15 42 34.44	9.559	85 39 42.2	0.795*n*	+2.11	− 0.4	28
12	6 40 24	+1 17.30	− 1 10.7	12 , 9	15 45 6.62	9.558	86 11 17.0	0.797*n*	+2.12	− 0.5	29
14	6 34 27	−1 21.78	+ 1 28.3	12 , 9	15 50 15.29	9.554	87 14 43.7	0.801*n*	+2.14	− 0.9	30
17	6 28 33	+1 34.15	− 4 47.4	12 , 9	15 58 8.71	9.552	88 50 52.1	0.807*n*	+2.18	− 0.8	31
18	6 20 56	+0 37.50	+ 1 25.0	12 , 9	16 0 48.91	9.546	89 23 2.0	0.809*n*	+2.19	− 1.0	32
19	6 48 21	+1 20.71	− 2 39.4	12 , 9	16 3 34.60	9.572	89 55 57.8	0.811*n*	+2.21	− 1.0	33
20	6 23 29	−2 48.32	+ 9 10.3	9 , 12	16 6 15.89	9.551	90 27 51.4	0.812*n*	+2.23	− 1.5	34
21	6 14 57	+0 58.32	− 5 26.8	9 , 6	16 9 0.53	9.543	91 0 12.8	0.814*n*	+2.24	− 1.2	35
22	6 13 6	+0 51.95	− 1 19.1	9 , 6	16 11 46.87	9.543	91 32 54.8	0.816*n*	+2.25	− 1.3	36
					Comète périodique Schaumasse (1919 d)						
Nov. 30	17 12 32	−1 9.48	+ 2 58.1	9 , 6	13 54 33.16	9.547*n*	90 48 20.1	0.813*n*	+2.61	+14.6	37
30	17 49 42	−1 4.79	+ 3 22.4	6 , 3	13 54 37.85	9.501*n*	90 48 44.4	0.814*n*	+2.61	+14.6	37
					Comète périodique Finlay (1919 e)						
Nov. 13	6 36 38	+2 0.14	+ 3 1.1	9 , 6	23 1 16.29	9.005*n*	98 32 16.7	0.861*n*	+3.96	−25.6	38
13	7 10 43	+2 41.95	+ 1 17.3	9 , 6	23 1 58.10	8.624*n*	98 30 32.9	0.862*n*	+3.96	−25.6	38
Dec. 10	6 7 8	+1 1.20	− 1 40.0	9 , 6	1 49 57.79	9.401*n*	74 55 54.9	0.698*n*	+4.88	−24.6	39
11	6 34 58	−1 24.00	+ 2 37.5	9 , 6	1 54 3.88	9.323*n*	74 28 16.6	0.685*n*	+4.93	−24.2	40
13	6 3 3	+3 11.91	− 1 40.4	9 , 12	2 1 42.53	9.414*n*	73 38 27.8	0.688*n*	+4.96	−24.0	41
					(5) *Astrée*						
Oct. 18	10 21 33	+0 25.41	+ 1 3.5	9 , 6	0 57 14.41	8.942*n*	91 18 56.4	0.819*n*	+4.50	−26.8	42
19	9 55 48	−0 20.60	− 2 25.9	6 , 6	0 56 25.15	9.090*n*	91 24 34.6	0.819*n*	+4.50	−26.8	43
20	10 23 21	−0 34.55	− 0 10.2	9 , 6	0 55 34.16	8.832*n*	91 30 24.5	0.821*n*	+4.50	−26.7	44
21	10 25 5	−1 24.14	+ 5 21.6	9 , 6	0 54 44.57	8.752*n*	91 35 56.3	0.821*n*	+4.50	−26.7	44
					(11) *Parthenope*						
Mai 22	11 20 2	+0 39.45	− 0 20.3	9 , 6	13 48 52.11	9.183	93 25 45.7	0.832*n*	+3.22	+14.9	45
23	10 56 56	+0 6.37	− 1 23.0	9 , 6	13 48 19.03	9.085	93 24 42.9	0.832*n*	+3.22	+14.8	45
26	10 18 20	−1 25.04	− 3 31.3	9 , 12	13 46 47.61	8.896	93 22 34.4	0.833*n*	+3.21	+14.6	45
27	9 51 32	−1 52.36	− 3 50.9	9 , 12	13 46 20.29	8.596	93 22 14.8	0.833*n*	+3.21	+14.6	45
28	10 18 18	−2 19.28	− 4 1.3	9 , 12	13 45 53.36	8.976	93 22 4.3	0.832*n*	+3.20	+14.5	45
					(16) *Psyche*						
Août 18	11 20 20	+3 5.52	− 3 57.1	9 , 12	20 17 16.01	8.942	108 2 19.7	0.902*n*	+4.49	−18.6	46
19	10 45 24	+2 26.27	− 0 29.3	9 , 9	20 16 36.76	8.506	108 5 47.5	0.904*n*	+4.49	−18.6	46
20	11 17 53	+1 16.59	+ 3 6.9	9 , 6	20 15 57.08	8.999	108 9 23.7	0.901*n*	+4.49	−18.6	46

Date	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		*
					(22) *Calliope*						
19	h m	m s	′ ″		h m s		° ′ ″		s	″	
Mai 20	10 46 17	+1 10.28	− 7 31.1	12 , 12	13 55 23.03	8.853	91 34 12.3	0.821*n*	+3.23	+14.3	47
21	11 30 50	−1 49.33	− 6 1.7	12 , 12	13 54 43.97	9.187	91 35 41.6	0.821*n*	+3.22	+14.2	47
22	11 55 1	−2 26.94	− 4 26.0	9 , 8	13 54 6.36	9.299	91 37 17.2	0.820*n*	+3.22	+14.1	47
23	11 21 54	−3 2.06	− 2 47.5	9 , 12	13 53 31.24	9.188	91 38 55.7	0.821*n*	+3.22	+14.1	47
					(46) *Hestia*						
Févr. 4	10 25 0	−0 9.80	+ 2 18.8	12 , 9	5 3 56.04	9.380	70 16 55.5	0.644*n*	+2.36	− 2.4	48
					(52) *Europa*						
Mai 26	10 58 37	−0 7.03	− 0 52.8	12 , 9	15 58 17.80	8.908*n*	100 23 40.6	0.871*n*	+3.66	+ 7.2	49
27	10 22 52	−0 52.81	− 2 16.0	9 , 6	15 57 32.03	9.128*n*	100 22 17.3	0.869*n*	+3.67	+ 7.1	49
28	11 3 29	−1 40.85	− 3 39.5	9 , 6	15 56 43.99	8.748*n*	100 20 53.8	0.871*n*	+3.67	+ 7.1	49
31	11 13 15	−1 15.52	− 3 31.7	9 , 6	15 54 24.96	8.107*n*	100 17 24.3	0.871*n*	+3.69	+ 7.1	50
Juin 2	11 34 47	−2 46.93	− 5 29.6	9 , 12	15 52 53.57	8.616	100 15 26.3	0.871*n*	+3.71	+ 7.0	50
					(56) *Melete*						
Mai 31	10 25 29	−1 26.47	+12 50.7	9 , 6	12 27 26.83	9.391	90 2 51.2	0.811*n*	+2.77	+16.3	51
Juin 2	10 7 57	−0 57.14	+11 49.5	9 , 6	12 27 56.14	9.365	90 1 49.9	0.811*n*	+2.75	+16.2	51
					(66) *Maia*						
Oct. 19	11 2 31	−0 54.12	+ 7 21.3	9 , 6	0 44 39.17	8.079	84 8 56.8	0.765*n*	+4.56	−27.8	52
20	11 50 13	+1 49.16	− 8 15.8	9 , 6	0 43 48.56	9.018	84 12 30.2	0.767*n*	+4.55	−28.0	53
21	11 46 40	+1 0.82	− 4 56.9	9 , 6	0 43 0.22	9.025	84 15 49.1	0.767*n*	+4.55	−28.0	53
					(89) *Julie*						
Août 18	11 47 29	+0 34.96	− 7 35.4	9 , 6	20 59 49.70	8.766	103 2 16.5	0.883*n*	+4.39	−22.5	54
19	11 39 5	+1 37.47	+ 5 37.5	9 , 6	20 58 43.57	8.720	102 56 39.9	0.883*n*	+4.39	−22.4	55
					(148) *Gallia*						
Avril 19	10 31 29	−1 37.30	− 1 56.4	12 , 9	10 53 53.68	9.200	66 35 21.6	0.569*n*	+2.78	+13.4	56
22	9 33 29	−2 6.16	− 6 38.7	9 , 12	10 53 24.79	8.875	66 30 38.9	0.552*n*	+2.75	+13.0	56
					(186) *Celuta*						
Oct. 20	11 17 49	+1 32.51	−2 31.4	9 , 6	0 48 20.32	8.602	82 20 38.8	0.749*n*	+4.59	−27.9	57
21	11 25 36	+0 26.61	−4 26.2	9 , 6	0 47 14.42	8.798	82 18 43.9	0.749*n*	+4.59	−28.0	57
					(221) *Eos*						
Avril 19	11 19 21	+1 33.73	− 5 46.4	12 , 9	11 20 52.93	9.266	76 37 38.8	0.702*n*	+2.80	+16.4	58
22	11 36 23	−0 59.16	− 1 25.8	12 , 9	11 19 53.56	9.364	76 31 40.0	0.710*n*	+2.78	+16.1	59
					(240) *Vanadis*						
Oct. 18	9 55 58	+1 26.27	− 1 17.3	9 , 6	0 15 10.38	8.771*n*	92 17 0.8	0.826*n*	+4.42	−28.1	60
19	9 35 16	+0 47.41	+ 2 28.1	9 , 6	0 14 31.52	8.940*n*	92 20 46.2	0.826*n*	+4.42	−28.1	60
20	10 0 55	+0 8.44	+ 6 8.0	9 , 6	0 13 52.55	8.539*n*	92 24 26.2	0.827*n*	+4.42	−28.0	60
21	10 4 24	−0 28.58	+ 9 35.6	9 , 6	0 13 15.53	8.304*n*	92 27 53.8	0.827*n*	+4.42	−28.0	60

Date	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		✱
19	h m s	m s	′ ″		h m s		° ′ ″		s	″	
					(259) *Altheia*						
Juin 2	10 49 50	−1 51.63	− 8 56.5	12 , 12	13 48 41.14	9.239	89 14 44.5	0.806*n*	+3.14	+13.1	61
					(268) *Adorea*						
Mai 22	10 44 51	−0 42.86	+ 2 23.3	9 , 6	12 5 58.42	9.405	87 15 40.0	0.794*n*	+2.72	+16.6	62
23	10 33 52	−0 31.75	+ 4 29.9	9 , 6	12 6 9.52	9.388	87 17 46.5	0.795*n*	+2.71	+16.5	62
					(336) *Lacadiera*						
Oct. 20	9 38 42	+1 31.00	− 3 47.2	9 , 6	23 45 16.71	8.367*n*	84 20 33.9	0.767*n*	+4.38	−29.9	63
21	9 30 53	−1 45.81	+ 2 44.8	9 , 6	23 44 46.90	8.467*n*	84 28 1.0	0.768*n*	+4.38	−29.9	64
					(349) *Dembowska*						
Mai 21	9 34 59	−0 29.22	− 7 49.8	12 , 9	10 42 24.18	9.439	75 46 55.1	0.713*n*	+2.30	+13.3	65
22	9 47 45	+0 31.07	− 6 51.3	9 , 6	10 42 50.75	9.471	75 52 36.5	0.720*n*	+2.28	+13.3	66
23	9 29 24	+0 57.66	− 1 12.9	12 , 6	10 43 17.33	9.441	75 58 14.8	0.715*n*	+2.27	+13.2	66
					(416) *Vaticana*						
Avril 19	9 44 45	−1 4.37	− 0 31.9	12 , 9	11 11 40.58	8.594	67 4 4.3	0.558*n*	+2.82	+13.9	67
22	10 18 2	−3 13.57	− 2 3.2	12 , 12	11 10 33.40	9.098	67 20 47.9	0.573*n*	+2.80	+13.6	68
Mai 21	10 5 41	−2 43.16	− 7 16.4	12 , 12	11 12 28.57	9.450	71 19 49.9	0.671*n*	+2.46	+11.9	69
22	10 16 25	−2 16.13	+ 2 59.0	9 , 9	11 12 55.61	9.480	71 30 5.2	0.680*n*	+2.47	+11.8	69
23	9 52 30	−3 29.58	− 1 1.7	9 , 12	11 13 23.00	9.436	71 40 15.6	0.671*n*	+2.44	+11.8	70
					(444) *Gyptis*						
Oct. 18	10 50 14	+1 14.21	− 1 18.4	9 , 6	0 46 41.29	8.281*n*	85 29 4.3	0.776*n*	+4.54	−27.7	71
19	10 20 16	+0 37.75	+ 8 17.1	9 , 6	0 46 4.84	8.804*n*	85 38 39.8	0.778*n*	+4.55	−27.7	71
20	10 46 52	−0 53.21	− 3 56.5	9 , 6	0 45 27	7.961*n*	85 48 23	0.778*n*	+4.54	−27.7	72
21	11 1 18	−0 46.87	−10 48.3	9 , 6	0 44 51.22	8.374	85 58 8.4	0.780*n*	+4.54	−27.7	73

Positions des étoiles de Comparaison

✱	A.R. moy.	D.P. moy.	Autorités		✱	A.R. moy.	D.P. moy.	Autorités	
	h m s	° ′ ″				h m s	° ′ ″		
1	5 52 37.40	97 38 33.1	*A.G. Wien-Ottak.*	1702	13	19 30 48.22	98 13 34.9	*A.G. Wien-Ottak.*	6821
2	5 56 33.49	97 28 19.7	*A.G. Wien-Ottak.*	1727	14	19 35 41.90	98 9 39.6	*A.G. Wien-Ottak.*	6861
3	6 58 40.93	70 39 23.9	*A.G. Berlin A*	2564	15	19 54 48.77	97 55 48.1	*A.G. Wien-Ottak.*	7012
4	7 3 49.23	63 6 4.5	*A.G. Camb.(Eng.)*	3761	16	19 59 54.88	97 57 54.7	*A.G. Wien-Ottak.*	7053
5	7 0 36.20	56 7 58.4	*A.G. Leiden*	2963	17	22 45 57.79	59 42 50.2	*A.G. Leiden*	9690
	1919.0	1919.0			18	22 45 29.52	59 37 31.7	*A.G. Leiden*	9686
6	6 42 23.79	29 26 40.4	*A.G. Helsingfors*	4722	19	22 38 45.18	54 44 34.5	*A.G. Leiden*	9629
7	6 43 3.58	28 58 24.4	*A.G. Helsingfors*	4727	20	22 30 38.48	49 0 22.0	rap. a Star *A G; Bonn*	16892
8	6 33 1.46	24 56 26.1	*A.G. Christiania*	1068	21	14 6 1.11	63 46 17.6	*A.G. Cam.(Eng.)*	6734
9	6 26 10.25	24 39 30.3	*A.G. Christiania*	1051	22	14 11 14.48	64 36 43.3	*A.G. Cam.(Eng.)*	6763
10	6 31 16.46	23 46 5.8	*A.G. Christiania*	1063	23	14 13 20.53	65 7 38.9	*A.G. Cam.(Eng.)*	6780
11	19 26 18.38	98 21 21.2	*A.G. Wien-Ottak.*	6785	24	14 14 17.82	66 1 2.0	*A.G. Berlin B*	5035
12	19 30 55.69	98 16 44.2	*A.G. Wien-Ottak.*	6822	25	14 58 51.12	76 12 55.9	*A.G. Leipzig I*	5277

*	A.R. moy.	D.P. moy.	Autorités	*	A.R. moy.	D.P. moy.	Autorités
	h m s	° ′ ″			h m s	° ′ ″	
26	15 4 56.09	77 36 46.8	rap. a Star *A.G. Lpzg. I* 5306	50	15 55 36.79	100 20 48.9	rap. a Star *A.G. Cam.* (*U.S.*) 5543
27	15 18 53.61	80 6 43.5	*A.G. Leipzig I* 5370	51	12 28 50.53	89 49 44.2	*A.G. Nicolajew* 3427
28	15 41 29.17	85 43 7.6	*A.G. Albany* 5277	52	0 45 28.73	84 2 3.3	*A.G. Leipzig II* 273
29	15 43 47.20	86 12 28.2	*A.G. Albany* 5288	53	0 41 54.85	84 21 14.0	*A.G. Leipzig II* 253
30	15 51 34.93	87 13 16.3	*A.G. Albany* 5317	54	20 59 10.35	103 10 14.4	*A.G. Cam.(U.S.)* 7464
31	15 56 32.38	88 55 40.3	*Abbadia* 8691	55	20 57 1.71	102 51 24.8	*A.G. Cam.(U.S.)* 7445
32	16 0 9.22	89 21 38.0	*A.G. Nicolajew* 4042	56	10 55 28.20	66 37 4.6	*A.G. Berlin B* 4150
33	16 2 11.68	89 58 38.2	*A.G. Nicolajew* 4049	57	0 46 43.22	82 23 38.1	*A.G. Leipzig II* 285
34	16 9 1.98	90 18 42.6	*A.G. Nicolajew* 4076	58	11 19 16.40	76 43 8.8	*A.G. Leipzig I* 4279
35	16 7 59.97	91 5 40.8	rap. a Star *A.G. Nicolajew* 4077	59	11 20 49.94	76 32 49.7	*A.G. Leipzig I* 4288
36	16 10 52.67	91 34 15.2	*A.G. Nicolajew* 4090	60	0 13 39.69	92 18 46.2	*A.G. Strasbourg* 57
37	13 55 40.03	90 45 7.4	*Munich*$_1$ 9705	61	13 50 29.63	89 23 27.9	rap. a Star *A.G. Nicolajew* 3659
38	22 59 42.19	98 29 41.2	*A.G. Wien-Ottak.* 8197	62	12 6 38.56	87 13 0.1	*A.G. Albany* 4442
39	1 48 51.71	74 57 59.5	*A.G. Leipzig I* 564	63	23 43 41.33	84 24 51.0	rap. à star 64
40	1 55 22.95	74 26 3.3	*A.G. Berlin A* 571	64	23 46 28.33	84 25 46.1	*A.G. Leipzig II* 11786
41	1 58 25.66	73 43 32.2	*A.G. Berlin A* 583	65	10 42 51.40	75 54 31.6	*A.G. Leipzig I* 4112
42	0 56 44.50	91 18 19.7	*A.G. Nicolajew* 196	66	10 42 17.40	75 59 14.5	*A.G. Leipzig I* 4107
43	0 56 41.25	91 27 27.3	*A.G. Nicolajew* 195	67	11 12 42.13	67 1 22.3	rap. a Star *A.G. Berlin B* 4227
44	0 56 4.21	91 31 1.4	*A.G. Nicolajew* 193	68	11 13 44.17	67 22 37.5	*A.G. Berlin B* 4232
45	13 48 9.44	93 25 51.1	*A.G. Strasbourg* 4962	69	11 15 9.27	71 26 54.4	*A.G. Berlin A* 4406
46	20 14 6.00	108 6 35.4	*Bordeaux* 6101	70	11 16 50.14	71 41 5.5	*A.G. Berlin A* 4413
47	13 56 30.08	91 41 39.1	*A.G. Nicolajew* 3669	71	0 45 22.54	85 30 50.4	*A.G. Albany* 210
48	5 4 3.48	70 14 39.1	*A.G. Berlin A* 1403	72	0 46 15	85 52 47	*B.D.* +3° 112
49	15 58 21.17	100 24 26.2	*A.G. Cam.(U.S.)* 5557	73	0 45 33.55	86 9 24.4	*A.G. Albany* 211

* 20 — *A.G. Bonn*	16892	: Δ *A.R.* = −0ᵐ 42ˢ.97	; Δ *D.P.* = + 9′ 36″.5
* 26 — *A.G. Leipzig I*	5306	: Δ *A.R.* = +1 6.94	; Δ *D.P.* = − 6 20.8
* 35 — *A.G. Nicolajew*	4077	: Δ *A.R.* = −1 3.98	; Δ *D.P.* = − 5 55.3
* 50 — *A.G.Cam.(U.S.)*	5543	: Δ *A.R.* = +0 21.80	; Δ *D.P.* = −13 21.6
* 61 — *A.G. Nicolajew*	3659	: Δ *A.R.* = −2 11.61	; Δ *D.P.* = − 1 45.6
* 63 — * 64		: Δ *A.R.* = −2 47.00	; Δ *D.P.* = − 0 55.1
* 67 — *A.G. Berlin B*	4227	: Δ *A.R.* = +0 11.28	; Δ *D.P.* = −12 46.5

REMARQUES

Les remarques sur les Comètes ci-dessous sont faites à l'aide du grossissement 124, sauf pour la Comète Metcalf (1919 *b*) pour laquelle le faible grossissement 66 est nécessaire:

Comète périodique Borrelly (1905 II).— Octobre 9, Comète de grandeur 11.5, noyau allongé, tête large de 30″. Novembre 23, Comète de grandeur 9.5, noyau bien défini, mais flou, au centre de la chevelure, large de 50″, qui semble s'allonger vers *WNW*. Novembre 30, un vent du *NE* agite la lunette. Decembre 6, Comète de 9 grandeur, tête ronde, étalée sur 1.5 de diamètre, noyau central bien prononcé, naissance de queue vers *E* sur 3′ de longueur. Janvier 21, Comète de 10 grandeur. Fébrier 4, Comète de 12 grandeur; le ciel est nébuleux.

Comète périodique Kopff (1919 *a*).— Août 16, au début de l'observation, la Comète est estimée de 11 grandeur, mais, vers la fin, l'éclat est très atténué par le lever de la Lune et la formation de vapeurs nuageuses. Août 18, le ciel est beau, la Comète, de grandeur 10.5, apparaît ronde; la chevelure a un diamètre voisin de 1.5 avec, sensiblement au centre, une condensation écrasée et floue. Août 28, un vent violent du *SW* secoue la lunette. Septembre 25, la Comète de grandeur 12.5 est à la limite de visibilité: les pointés sont pénibles.

Comète METCALF (1919 *b*).— Août 23, la Comète, de 9 grandeur, apparaît très nébuleuse, circulaire, large d'environ 5′ avec, au centre, une condensation étalée, sans noyau précis. Août 27, la Comète, toujours de 9 grandeur a un diamètre de 8′ à 10′, le noyau incertain disparait aux pointés.

Comète METCALF-BORRELLY (1919 *c*).— Août 25, Cette Comète, estimée de 10 grandeur, est relativement lumineuse; elle est ronde, mesure 2′ de diamètre et a une condensation centrale nébuleuse, mais bien définie. Août 28, la lunette est secouée sous l'action d'un fort vent du *SW*. Août 30, la Comète est de 9 grandeur. Septembre 22, l'observation est faite un peu trop près de l'horizon. Octobre 11, la Comète disparait sous les nuages. Octobre 12, la Comète est de 8 grandeur, la condensation est centrale et toujours bien définie. Octobre 14, à $6^h\ 29^m$ la Comète passe devant une étoile de 11 grandeur sans que l'éclat de cette dernière en soit altérée. Octobre 17, la Comète est de grandeur 7.5. Octobre 19, le ciel est nuageux et les mesures difficiles. Octobre 21, la Comète, estimée de 8 grandeur, n'apparait dans le crépuscule qu'avec les étoiles de 10 grandeur.

Comète périodique SCHAUMASSE (1919 *d*).— Novembre 30, la Comète à l'aspect d'une petite nébulosité de 12 grandeur, large de 30″ à 40″, disparaissant aux premières lueurs de l'aurore.

Comète périodique FINLAY (1919 *e*).— Novembre 13, la Comète, de 9 grandeur, est d'un aspect vaporeux; la chevelure, circulaire, s'estompe sur un diamètre de 4′ à 5′; le noyau, décentré, vers le *SSW*, est mal défini. Decembre 10, la Comète, de grandeur 10.5, est difficile à pointer par suite du noyau incertain.

Planétes.— (11) *Parthenope*, Mai 27, le ciel est vaporeux; Mai 28, la lunette est secouée par le vent. (56) *Melete*, Juni 2, vent assez fort. (66) Maia, Octobre 19, les images sont un peu agitées sous l'influence du vent.

Observatoire de Besançon,
1920, Avril 10.

PHOTOGRAPHIC DETERMINATIONS OF THE PARALLAXES OF 46 STARS WITH THE THAW REFRACTOR,

BY ZACCHEUS DANIEL AND FRANK SCHLESINGER

The measurements for this series of parallaxes were all made by MR. DANIEL. The average probable error is ″.0081, the average number of plates is 15.5, and the average number of comparison stars is 3.8. The numbers assigned to the stars are in continuation of earlier series. The full details of this work will be printed in the *Publications of the Allegheny Observatory*.

No.	Name	α (1900)	δ (1900)	Visual Magn. and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error
		h m	° ′		″	″ ″
320	*Piazzi* 267	0 0	+34 6	6.2 F0	0.77	+.040 ±.009
321	Σ42 (brighter)	31	+29 27	9.0	.45	+.032 6
322	Σ42 (fainter)	31	+29 27	9.8	..	+.013 10
..	Mean	....	.....	8.6 F8	..	+.027 5
323	54 *Piscium*	34	+20 43	6.1 K0	.60	+.096 7
324	55 *Piscium*	35	+20 53	5.6 K0	.05	+.003 6
325	*Lalande* 4045	0 35	+39 39	7.5 K0	.80	+.068 6
326	β *Andromedæ*	1 4	+35 5	2.4 Ma	.22	+.033 7
327	*Piazzi* 142	36	+42 7	5.1 F8	.82	+.081 7
328	9 λ *Arietis*	1 52	+23 7	4.8 A5	.09	+.023 8
329	8 δ *Trianguli*	2 11	+33 46	5.1 G0	1.18	+.062 8
330	*Piazzi* 123	2 31	+ 6 25	5.9 K0	2.32	+.145 8
331	10 *Tauri*	3 32	+ 0 5	4.4 G5	.53	+.055 10
332	38 *o Persei*	3 38	+31 58	3.9 B1	.028	.000 7
333	*Groombridge* 864	4 35	+11 56	7.3 G0	.69	+.021 7
334	*Companion to Capella*	5 10	+15 14	10.5	.42	+.071 8

No.	Name	α (1900)	δ (1900)	Visual Magn. and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error	
		h m	° ′		″	″	″
335	*η Geminorum*	6 9	+22 32	Var. Ma	.06	+.016	±.008
336	*Lalande* 12293	6 22	+36 33	7.1 G0	.39	+.032	7
337	19 *Lyncis* (fainter)	7 15	+55 28	6.5 A	....	−.004	7
338	19 *Lyncis* (brighter)	7 15	+55 28	5.6 B8	...	+.007	8
...	Mean	.	...	...	.033	+.001	5
339	*o Leonis*	9 36	+10 21	3.8 F5	.15	+.024	8
340	60 *Leonis*	10 57	+20 13	4.1 A	.029	+.007	8
341	*Piazzi* 40	12 14	+17 6	7.0 G5	.24	+.019	8
342	*Lalande* 24414	13 4	+ 5 16	6.9 G0	.68	+.035	9
343	Σ 2106	16 46	+ 9 35	6.8 F8	....	−.004	9
344	Σ 2128	17 2	+59 43	9.1 K0	.43	+.039	8
345	*Weisse* 1805	17 58	+26 20	7.1 K0	.72	+.035	11
346	*Lalande* 33439	18 6	+38 27	6.4 G	.58	+.095	6
347	111 *Herculis*	18 43	+18 4	4.4 A3	.13	+.051	9
348	31 *b Aquilæ*	19 20	+11 44	5.2 G5	.96	+.055	11
349	38 *μ Aquilæ*	29	+ 7 10	4.6 K	.27	+.016	8
350	*Groombridge* 2875	29	+58 23	6.7 G0	.66	+.025	6
351	*Lalande* 37120	30	+32 59	6.6 K0	.52	+.027	10
352	17 *Cygni*	19 43	+33 30	5.0 F5	.45	+.030	7
353	*Lalande* 38383	20 0	+23 5	7.2 K2	1.37	+.038	7
354	*Lalande* 38380	0	+29 38	5.7 K	.86	+.044	7
355	*Groombridge* 3243	34	+12 29	7.1 F8	.20	−.005	9
356	*Oeltzen* 21338	51	+61 48	8.6 K2	.77	+.134	7
357	*Lalande* 40848	59	+45 29	8.1 K2	.40	+.044	9
358	β 1138	20 59	+45 27	6.2 B8	...	−.004	11
359	*Lalande* 41685	21 21	+ 0 41	6.4 F2	.19	+.047	10
360	*Lalande* 41818	25	+11 50	7.7 G0	.18	+.001	8
361	*Lalande* 42286	37	+26 18	7.4 G5	.36	+.028	7
362	*μ Cephei*	40	+58 19	Var. Ma	.004	+.005	8
363	*Lalande* 42843	21 53	+ 3 18	7.1 F8	.31	+.025	10
364	*Lalande* 43492	22 12	+12 24	6.9 G0	.85	+.033	9
365	*Piazzi* 218	23 48	+74 59	6.5 K0	.33	+.092	5

CORRECTION. No. 770, p. 12, of π χ Pegasi (No. 161) should be $-''.010 \pm ''.006$, not $+''.010 \pm ''.006$.

Allegheny Observatory of the University of Pittsburgh,
March 20, 1920.

THE PARALLAX OF *NOVA AQUILAE* NO. 3,

By F. HENROTEAU.

The valuable paper "Observations de *Nova Aquilæ* No. 3 effectuées en 1918" published in the recent volumes of the "*Annales de l'Observatoire Royal de Belgique*" in which determinations of the parallax of this star are given by H. PHILIPPOT and E. DELPORTE, having come to our attention, a redetermination of the parallax, based on the data they have obtained with their meridian circle, was undertaken. We shall treat MR. PHILIPPOT's data anew; our reason for so doing will appear to the reader in the course of the paper.

In MR. PHILIPPOT's treatment of his observations the proper motion of the star is entirely neglected. However it is well known that for all the stars, yearly displacements due to proper-motion are of about the same order of magnitude as displacements due to parallax. When computing parallax proper-motion must be considered.

In our new determination of the parallax we shall make use of the means of the differences $\alpha - \alpha_i$; (right ascension of the *Nova* minus right ascension of each comparison star) for the seven comparison stars

B. D. $+0°.3982$, 3993, 4005, 4039, 4051, 4061, and 4082, on each date. (See Mr. Philippot's table on p. 41 of his memoir.)

We shall reduce these means into thousandths of seconds of arc and obtain values of m given in the following table, by subtracting a convenient constant from these means, a constant so chosen as to render m as small as possible. As the seven comparison stars were not observed on June 12, June 17 and July 15, no m has been computed for these dates.

Data of Observation

Date	p	P	m	t	v
June 13	0.6	+.33	+974	0.00	+646
18	0.6	+.25	+143	0.05	−168
25	0.6	+.13	−193	0.12	−480
July 18	0.6	−.25	−234	0.35	−443
24	0.8	−.35	+ 61	0.41	−127
29	0.8	−.42	+597	0.46	+426
31	1.0	−.46	+239	0.48	+ 75
Aug. 7	0.8	−.55	− 74	0.55	−213
21	1.0	−.73	+256	0.69	+167
Sept. 16	0.8	−.95	− 49	0.95	− 41
25	0.8	−.99	− 52	1.04	− 10

(1) In the above table p is a weight given to each observation according to the quality of the seeing noted by the observers on the corresponding dates. (Seeing I carries a weight 1.0, II a weight 0.8, and III a weight 0.6.)

(2) P is the parallactic factor, or factor by which to multiply the parallax of the star to obtain its parallactic displacement in right ascension. P is given by the formula

$$P = R\ (\sin\,(\odot - \alpha) - 2\sin^2 \tfrac{1}{2}\,\epsilon \sin\odot\cos\alpha)$$

in which R is the radius vector of the *Earth* in its orbit varying between 0.983 and 1.017, ϵ is the inclination of the ecliptic or 23° 27′, $\odot$ is the longitude of the *Sun* for the date of observation and α is the right ascension of the star.

(3) m has been defined above.

(4) t is the time elapsed expressed in fractions of 100 days, taking the epoch 1918 June 13 as origin.

We know that we have the relation

$$m = c + t\mu + P\pi$$

in which c is a constant, μ is the proper-motion of the star for 100 days and π is its parallax. Establishing these equations for each of the above dates we have a system of eleven condition equations to determine c, μ and π.[1]

A least square solution gives us the following equations:

$$\begin{aligned} +8.400\,c + 4.210\,\mu - 3.522\,\pi &= +1296 \\ +4.210\,c + 2.923\,\mu - 2.818\,\pi &= +\ 360 \\ -3.522\,c - 2.818\,\mu + 2.879\,\pi &= -\ 170 \end{aligned}$$

$$\text{Hence}\quad \begin{cases} \pi = -\ 40 \\ \mu = -407 \\ c = +341 \end{cases}$$

or expressed in seconds

$$\begin{aligned} \pi &= -0''.04\ \pm 1''.14 \\ \mu &= -0''.41\ \pm 1''.47 \end{aligned}$$

The probable error for an observation of weight unity is $\pm 0''.206$. Having then computed $m' = c + t\,\mu + P\pi$ for each date with these values of π, μ and c, we find the residuals $v = m - m'$ given in the above table. It will be observed that the residuals are much larger at the beginning than at the end; this might be attributed to better seeing for the later observations; however, we are more inclined to believe that the much greater brightness of the *Nova* in June would increase the personal equation of the observer very markedly. To sum up it seems that the value obtained for the parallax of *Nova Aquilæ* from the above data has practically no meaning and only seems to indicate that it is very small and that the star is exceedingly remote from us. Preliminary parallaxes obtained photographically by Olivier and Trümpler indicate that only an absolute parallax smaller than $0''.01$ is to be considered.

Dominion Observatory, Ottawa, Canada,
April 28, 1920.

[1] See "*Les Etoiles Simples*" by F. Henroteau, p. 124 (Paris, Gaston Doin, editor.)

CONTENTS.

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ON AN ANOMALY IN STAR CATALOGS,

By H. R. MORGAN.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

It has been the custom to correct the observed places of the stars for that part of aberration which is due to the motion of the *Earth* around the *Sun*, and to call the mean place of a star its real place as affected by the aberration due to the motion of the solar system in space. Recent determinations of this latter motion indicate an aberration of 15″ towards the apex, R. A., 18^h; Decl. +30°. Table I gives the amount by which present catalog positions differ from the positions the stars would have if the solar system were not in motion relatively to the stars. The stars are all shifted towards the apex by an amount varying from 0″ at apex, and antapex, to 15″ at 90° from these points.

TABLE I

α	0^h	2^h	4^h	6^h	8^h	10^h	12^h	14^h	16^h	18^h	20^h	22^h
						Δα						
δ	s	s	s	s	s	s	s	s	s	s	s	s
±89	−49.62	−42.98	−24.81	0.00	+24.81	+42.98	+49.62	+42.98	+24.81	0.00	−24.81	−42.98
±85	− 9.93	− 8.60	− 4.97	0.00	+ 4.97	+ 8.60	+ 9.93	+ 8.60	+ 4.97	0.00	− 4.97	− 8.60
±80	− 4.99	− 4.32	− 2.49	0.00	+ 2.49	+ 4.32	+ 4.99	+ 4.32	+ 2.49	0.00	− 2.49	− 4.32
±60	− 1.73	− 1.50	− 0.87	0.00	+ 0.87	+ 1.50	+ 1.73	+ 1.50	+ 0.87	0.00	− 0.87	− 1.50
±30	− 1.00	− 0.87	− 0.50	0.00	+ 0.50	+ 0.87	+ 1.00	+ 0.87	+ 0.50	0.00	− 0.50	− 0.87
0	− 0.87	− 0.75	− 0.43	0.00	+ 0.43	+ 0.75	+ 0.87	+ 0.75	+ 0.43	0.00	− 0.43	− 0.75
						Δδ						
°	″	″	″	″	″	″	″	″	″	″	″	″
+89	+ 0.1	+ 6.6	+11.4	+13.1	+11.4	+ 6.6	+ 0.1	− 6.4	−11.1	−12.9	−11.1	− 6.4
+80	+ 1.3	+ 7.7	+12.4	+14.1	+12.4	+ 7.7	+ 1.3	− 5.1	− 9.8	−11.5	− 9.8	− 5.1
+60	+ 3.8	+ 9.4	+13.5	+15.0	+13.5	+ 9.4	+ 3.8	− 1.9	− 6.0	− 7.5	− 6.0	− 1.9
+30	+ 6.5	+ 9.7	+12.1	+13.0	+12.1	+ 9.7	+ 6.5	+ 3.2	+ 0.9	0.0	+ 0.9	+ 3.2
0	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5	+ 7.5
−30	+ 6.5	+ 3.2	+ 0.9	0.0	+ 0.9	+ 3.2	+ 6.5	+ 9.7	+12.1	+13.0	+12.1	+ 9.7
−60	+ 3.8	− 1.9	− 6.0	− 7.5	− 6.0	− 1.9	+ 3.8	+ 9.4	+13.5	+15.0	+13.5	+ 9.4
−80	+ 1.3	− 5.1	− 9.8	−11.5	− 9.8	− 5.1	+ 1.3	+ 7.7	+12.4	+14.1	+12.4	+ 7.7
−89	+ 0.1	− 6.4	−11.1	−12.9	−11.1	− 6.4	+ 0.1	+ 6.6	+11.4	+13.1	+11.4	+ 6.6

If the motion and apex do not vary, this solar aberration, as it might be called, is practically constant as a vector on the sphere; but as precession changes the right ascensions and declinations both of

the apex and of the stars the amount of aberration in these coördinates changes. The approximate variations in 100 years of the aberration affects in Table I are given in Table II.

TABLE II

α	0^h	2^h	4^h	6^h	8^h	10^h	12^h	14^h	16^h	18^h	20^h	22^h
						$d\ (\Delta\alpha \cos\delta)$						
δ	″	″	″	″	″	″	″	″	″	″	″	″
+80	−0.76	−0.31	+0.47	+0.79	+0.37	−0.33	−0.68	−0.38	+0.26	+0.64	+0.33	−0.41
+60	−0.22	−0.07	+0.18	+0.29	+0.16	−0.08	−0.22	−0.15	+0.04	+0.14	+0.04	−0.15
+30	−0.08	0.00	+0.10	+0.14	+0.10	0.00	−0.08	−0.08	−0.01	0.00	−0.03	−0.08
0	0.00	+0.04	+0.06	+0.08	+0.06	+0.04	0.00	−0.04	−0.06	−0.08	−0.06	−0.04
−30	+0.08	+0.08	+0.01	0.00	+0.03	+0.08	+0.08	0.00	−0.10	−0.14	−0.10	0.00
−60	+0.22	+0.15	−0.04	−0.14	−0.04	+0.15	+0.22	+0.07	−0.18	−0.29	−0.16	+0.08
−80	+0.68	+0.38	−0.26	−0.64	−0.33	+0.41	+0.76	+0.31	−0.47	−0.79	−0.37	+0.33
						$d\ (\Delta\delta)$						
	″	″	″	″	″	″	″	″	″	″	″	″
+80	+0.01	+0.33	+0.30	−0.03	0.32	−0.30	+0.01	+0.31	+0.32	+0.02	−0.31	−0.32
+60	0.00	+0.11	+0.11	0.00	−0.11	−0.11	0.00	+0.11	+0.11	0.00	−0.11	−0.11
+30	0.00	+0.06	+0.06	0.00	−0.06	−0.06	0.00	+0.06	+0.06	0.00	−0.06	−0.06
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
−30	0.00	+0.06	+0.06	0.00	−0.06	−0.06	0.00	+0.06	+0.06	0.00	−0.06	−0.06
−60	0.00	+0.11	+0.11	0.00	−0.11	−0.11	0.00	+0.11	+0.11	0.00	−0.11	−0.11
−80	+0.01	+0.31	+0.32	+0.02	−0.31	−0.32	+0.01	+0.33	+0.30	−0.03	−0.32	−0.30

As Table I indicates the amount by which catalog positions are out, so Table II indicates the amount by which the catalog proper-motions do not represent the real motions of the stars. There is no serious objection to this anomaly in the catalogs, as it is well understood, and especially as accurate data as to solar motion are not now possible. However in statistical studies of proper-motions the quantities in Table II may have affect.

If future observations confirm the large velocity of 600 k. m., of our galaxy relatively to the spiral nebulæ, the aberration affects for such objects would be 27 times the size of the quantities in the above tables, as adjusted to the apex, R. A., 20^h; Decl., $-15°$. This "island universe" aberration for the greater magellanic cloud would be $\Delta\alpha$, $-47^s.12$; $\Delta\delta$, $-322''.8$, with changes in 100 years of $d(\Delta\alpha)$, $-1^s.34$; $d(\Delta\delta)$, $+6''.9$.

J. COMAS SOLA'S ASTEROID,

(Discovered 1920 January 13 at Barcelona, Spain.)

By E. E. BARNARD.

This object was telegraphed as a comet, but in these observations it appeared stellar. The seeing, however, was too poor to decide if there was any nebulosity about it and, later, moonlight interfered.

The position of January 21 given below is from a photograph with the 10-inch Bruce doublet. On this plate the trail was measured with respect to four comparison stars. The individual positions of the object from these measures agree to within a few tenths of a second in right ascension and $3'' - 4''$ in declination.

1920 Jan. 21, $8^h\ 50^m$ C. S. T. Appt. α $7^h\ 56^m\ 31^s.8$,
Appt. δ $+21°\ 34'\ 51''$.

The corrections to apparent were $+2^s.62$, $-12''.6$. The trail seems to be that of an asteroid.

On January 24 the object was 10 magnitude. On January 31 it was one and one half magnitude less than the comparison star, but the observation was in moonlight and haze.

Visual Measures of the Asteroid

Date	Cen. Stan. Time	$\Delta\alpha\cos\delta$	$\Delta\alpha$	$\Delta\delta$	Comps.	α App.	δ App.	log $p\Delta$		★
1920	h m s	"	m s	′ ″		h m s	° ′ ″			
Jan. 24	8 59 50	−166.7	−0 11.92	+3 9.7	4 , 6	7 52 50.53	+21 16 23.5	9.4624*n*	0.5575	1
24	13 46 35	+130.6	+0 9.34	+4 30.6	4 , 6	7 52 35.79	+21 15 8.3	9.4065	0.5490	2
27	11 30 4	+246.3	+0 17.61	−1 48.9	4 , 6	7 49 8.03	+20 56 50.5	8.3222	0.5079	3
29	11 45 53	+ 21.6	+0 1.94	+3 57.8	4 , 6	7 46 48.69	+20 41 0.6	8.8865	0.5115	4
31	8 56 28	+ 93.1	+0 6.63	+2 26.8	5 , 8	7 44 41.33	+20 31 54.7	9.3674*n*	0.5539	5
Feb. 3	11 30 27	+ 94.4	+0 6.70	−3 27.9	4 , 7	7 41 8.19	+20 3 33.7	8.9731	0.5315	6

Mean Places of Comparison Stars

★	α 1920.0	δ 1920.0	Red. to Appt.		Authority
	h m s	° ′ ″	s	″	
1	7 52 59.92	+21 13 25.1	+2.53	−12.4	10 mag. Compared with *Berlin* (*B*) *A. G. C.* 3191.
2	7 52 23.92	+21 10 50.1	+2.53	−12.4	*Berlin* (*B*) *A. G. C.* 3191.
3	7 48 47.78	+20 58 51.6	+2.64	−12.2	13.5 mag. Compared with *Berlin* (*B*) *A. G. C.* 3162.
4	7 46 44.12	+20 40 15.1	+2.63	−12.3	13 mag. Compared with *Berlin* (*B*) *A. G. C.* 3144.
5	7 44 32.05	+20 29 40.1	+2.65	−12.2	*B. D.* +20° 1911. R. H. TUCKER, *L. O. M. C.*
6	7 40 58.83	+20 7 13.6	+2.66	−12.0	*B. D.* +20° 1896. R. H. TUCKER, *L. O. M. C.*

Measures of Comparison Stars

Date		$\Delta\alpha\cos\delta$	$\Delta\alpha$	$\Delta\delta$	Comps.
		″	m s	′ ″	
1920 Jan. 24	Star 1 — *Berlin* (*B*) *A. G. C.* 3191	....	+0 36.00	+2 35.0	12 tr, 4
27	Star 3 — *Berlin* (*B*) *A. G. C.* 3162	+90.9	+0 6.50	−3 49.0	3 , 4
29	Star 4 — *Berlin* (*B*) *A. G. C.* 3144	...	+0 29.57	+2 22.0	14 tr, 3

The two stars *B. D.* +20° 1911 and +20° 1896 were kindly observed by PROFESSOR TUCKER with the Lick Observatory Meridian Circle. The epoch of the observations was 1920.17. System of *American Ephemeris*. There were two observations each. The estimated magnitudes were 9.6 and 9.4 respectively.

Yerkes Observatory, Williams Bay, Wisconsin,
February 4, 1920.

ADDITIONAL OBSERVATIONS OF SOLA'S ASTEROID

The following additional measures, which I have secured since the preceding observations, are added to the proof.

It is only justice to MR. SOLA to state here that he was not responsible for the asteroid being called a "comet" in the telegram sent to this country. His original announcement printed in *Beobachtung-Zirkular der Astronomischen Nachrichten* No. 4, 1920, Jan. 25, simply states that the asteroid was probably a new one. This error (the statement that it was a comet) may cause trouble in future references to the object. In PROFESSOR LOUIS LINDSEY's valuable paper in *Astro-*

nomical Journal No. 767, which gives elements and ephemeris of the asteroid, the word asteroid should be substituted throughout for "comet."

Visual Measures of the Asteroid

Date	Cent. Stan. Time	Δα cos δ	Δα	Δδ	Comps.	α App.	δ App.	log pΔ		★
1920	h m s	″	m s	′ ″		h m s	° ′ ″			
Feb. 10	7 25 49	−243.4	−0 17.21	−0 20.7	5 , 8	7 34 48.71*	+19 27 10.3	9.4786*n*	0.5966	7
10	8 6 19	−267.7	−0 18.94	−0 31.1	4 , 6	7 34 46.98	+19 26 59.9	9.3729*n*	0.5775	7
12	13 7 46	− 60.4	−0 4.26	−0 42.9	4 , 6	7 32 55.08	+19 12 40.9	9.5263	0.6170	8
14	7 16 9	−130.4	−0 19.19	−3 34.1	5 , 6	7 31 34.03	+19 1 17.6	9.4548*n*	0.5955	9
19	10 42 44	+150.4	+0 10.57	−3 36.4	4 , 6	7 28 11.39	+18 28 12.4	9.1703	0.5647	10
Mar. 9	10 11 20	+203.4	+ 14.15	+0 27.0	4 , 7	7 23 11.4	+16 33.6	9.3674	0.6075	11
May 8	8 31 42	− 99.1	−0 6.73	+0 31.3	4 , 6	8 7 49.98	+10 54 26.4	9.5527	0.7050	12
15	8 24 12	−104.3	−0 7.06	+3 12.0	3 , 6	8 16 42.86	+10 8 30.2	9.5658	0.7177	13
18	8 29 19	− 31.4	−0 2.12	+0 28.2	3 , 6	8 19 54	+ 9 52	9.5821	0.7226	14
25	8 40 38	+ 86.1	+0 5.81	−3 25.1	4 , 6	8 29 52±	+ 8 59.3	9.6075	0.7372	15

*Right ascension possibly a little uncertain.

Mean Places of Comparison Stars

★	α 1920.0	δ 1920.0	Red. to Appt.		Authority
	h m s	° ′ ″	s	″	
7	7 35 3.31	+19 27 42.5	+2.61	−11.5	13½ mag. Compared with *B. D.* +19° 1793.
8	7 32 56.74	+19 13 35.6	+2.60	−11.8	11 mag. Compared with Berlin *A. G. C.* 2939.
9	7 31 40.64	+19 5 3.4	+2.58	−11.7	11± mag. Compared with Berlin *A. G. C.* 2939.
10	7 27 58.29	+18 32 0.3	+2.53	−11.5	13.2 mag. Compared with Berlin *A. G. C.* 2886.
11	7 22 55.1	+16 33.3	+2.24	−11.5	10 mag. Compared with *B. D.* +16° 1476.
12	8 7 55.28	+10 54 8.8	+1.43	−13.5	12 mag. Compared with Leipzig *A. G. C.* 3307.
13	8 16 48.56	+10 5 31.8	+1.36	−13.6	12 mag. Compared with *Leipzig A. G. C.* 3365.
14	8 20 14	+ 9 52	+1.36	−13.5	12 mag. Position from corrected ephemeris of asteroid.
15	8 29 45±	+ 9 3±	+1.32	−13.7	12 mag. Position from corrected ephemeris of asteroid.

Measures of Comparison Stars

Date		Δα cos δ	Δα	δΔ	Comps.
		″	m s	′ ″	
1920 Feb. 10, Mar. 6, 9	Star 7 — *B. D.* +19° 1793	......	−0 36.80	−1 43.7	......
Feb. 14	Star 8 — *Berlin A. G. C.* 2939	+108.2	+0 7.64	+7 33.1	9 , 10
14	Star 9 — *Berlin A. G. C.* 2939	......	−1 8.46	−0 59.1	12tr, 4
19	Star 10 — *Berlin A. G. C.* 2886	+142.6	+0 10.03	−0 16.0	4 , 4
Mar. 20, 21, Apr. 13	Star 11 — *B. D.* +16° 1476	......	+1 19.16*	−3 17.3	10tr, 4
May 8	Star 12 — *Leipzig A. G. C.* 3307	.....	+0 49.62	−1 15.6	14tr, 4
15	Star 13 — *Leipzig A. G. C.* 3365	......	+0 58.22	−2 17.9	14tr, 3

*The two sets discordant by $0^s.16$.

The star *B. D.* +19° 1793 was compared with Berlin *A. G. C.* 2963.

$\Delta\alpha - 47''.3$ (4) $= -0^m\ 3^s.35$, $\Delta\delta - 3'\ 13''.3$ (4)

This gives for *B. D.* +19° 1793,

1920.0 $\alpha\ 7^h\ 35^m\ 40^s.11$, $\delta + 19°\ 29'\ 26''.2$

An intermediate star (*k*, 13 mag.) was compared with *B. D.* +19° 1793.

$\Delta\alpha - 311''.6$ (8) $= -0^m\ 22^s.03$, $\Delta\delta - 1'\ 10''.2$ (13)

This gives for *k*,

1920.0 $\alpha\ 7^h\ 35^m\ 18^s.08$, $\delta + 19°\ 28'\ 16''.0$

The star *k* was also compared with Star 7.

$\Delta\alpha + 208''.9$ (8) $= +0^m\ 14^s.77$, $\Delta\delta + 0'\ 33''.5$ (8)

In the measures for the position of Star 8 on February 14 an intermediate star, *A*, was used.

A — Berlin *A. G. C.* 2939
$\Delta\alpha + 238''.3$ (4) $= +0^m\ 16^s.82$, $\Delta\delta + 4'\ 37''.7$ (5)

Star 8 — *A*
$\Delta\alpha - 130''.1$ (5) $= -0^m\ 9^s.18$, $\Delta\delta + 2'\ 55''.7$ (5)

The following estimations of the brightness of the asteroid were made at the time of the observations.

Feb. 10 11 magnitude; $0^M.2$ fainter than Star 7.
12 Slightly brighter than Star 8.
14 $0^M.3$ fainter than the small star 1′ north following.
19 12.8 magnitude.
Mar. 9 12.7 magnitude.
May 8 12.9 magnitude.
15 13 magnitude.

E. E. B

May 20 1920.

COMMUNICATION. THE REDISCOVERY OF WOLF'S COMET IN 1918.

Gentlemen:

In *A. J.*, No. 763, Barnard writes with reference to the rediscovery of Wolf's Comet in 1918: "On July 16th, announcement was received in this country that it had been found on July 9th at Greenwich by Jonckheere who gave an approximate position of it (H. C. O. Bulletin No. 666). This was our first intimation that the comet had been seen elsewhere."

I would like to state that in *The Observatory* and *Nature* it was announced in May and June 1918 that I was searching with the 28-inch refractor of Greenwich for the reapparition of Wolf's Comet. After two months' labor I succeeded in locating it on the evening of July 9th. It was then near the 16th magnitude. Accurate positions were obtained all that night, and the *Astronomer Royal*, a few hours later, wired the complete and accurate coördinates to the Paris Observatory. Places were published in the *Comptes Rendus de l'Académie des Sciences* and in *Nature* and the magnitudes in *The Observatory*. I asked the *Astronomer Royal* to cable to America, but this expense he did not think necessary. I should certainly have done so had I been at Lille.

I do not know who sent a cable from Paris to Harvard College and cannot be held responsible for its delay or inaccuracy.

I am, Gentlemen,

Yours sincerely,

ROBERT JONCKHEERE.

Observatoire De L'Université, Lille, le 30 Mars, 1920

NOTE ON COMMUNICATION BY PROFESSOR JONCKHEERE.

Mr. Jonckheere's quotation from my paper in *Astronomical Journal* 763 correctly states the case. Full credit was given him in that paper for his rediscovery. The fact that he was searching for the comet in no way implied that he had found it. His discovery was entirely unknown in this country until the date specified in the quotation. No slight to Mr. Jonckheere was either implied or intended in my communication. E. E. BARNARD.

Yerkes Observatory, Williams Bay, Wisconsin, 1920, June 24.

OBSERVATIONS OF COMET d 1919, (FINLAY—SASAKI),

MADE WITH THE FILAR MICROMETER OF THE 433mm. REFRACTOR OF LA PLATA OBSERVATORY.

By NUMA TAPIA AND BERNHARD H. DAWSON.

1919	La Plata M.T.	★	Obs.	Comp.	☌—★ Δα	☌—★ Δδ	☌ Apparent Place α	☌ Apparent Place δ	log pΔ for α	log pΔ for δ
Nov. 24	10 23 2.2	1	D	8 , 8	−13.80	−2 47.2	0 28 16.65	+4 19 13.1	9.4041	0.7369n
24	10 40 36.7	1	T	10 , 10	− 9.82	−2 9.5	0 28 20.64	+4 19 50.8	9.4538	0.7351n
25	9 5 59.3	3	D	10 , 10	−23.22	+4 35.5	0 34 25.11	+5 12 33.1	8.9953	0.7505n
25	9 24 9.5	3	T	10 , 10	−19.35	+5 22.5	0 34 28.98	+5 13 20.1	9.1338	0.7496n
26	9 21 2.5	4	D	10 , 10	+16.72	−6 55.5	0 40 46.41	+6 7 18.3	9.0975	0.7576n
26	9 34 55.1	4	T	10 , 10	+20.20	−6 34.6	0 40 49.89	+6 7 39.2	9.1853	0.7567n
27	9 37 38.7	5	T	10 , 10	+ 8.63	+0 56.1	0 46 56.03	+6 59 48.5	9.1893	0.7639n
28	9 11 36.0	7	D	8 , 8	+ 0.93	+0 27.0	0 52 45.03	+7 48 32.4	8.9896	0.7725n
28	9 25 48.6	7	T	10 , 10	+ 4.44	+0 57.3	0 52 48.54	+7 49 2.7	9.1035	0.7715n

Mean Places of the Comparison Stars

★	α 1919.0	Red. to App. Pl.	δ 1919.0		
1	0 28 26.13	+4.33	+4 21 32.8	+27.4	Connected with ∗ 2. (D).
2	0 27 39.69	+4.33	+4 23 58.6	+27.4	*A. G. Albany* 98.
3	0 34 43.96	+4.37	+5 7 30.3	+27.3	*A. G. Albany* 141.
4	0 40 25.28	+4.41	+6 13 46.4	+27.4	*A. G. Leipzig II* 242.
5	0 46 42.96	+4.44	+6 58 25.1	+27.3	Connected with ∗ 6. (T).
6	0 45 56.54	+4.44	+7 0 7.3	+27.3	*A. G. Leipzig II* 276.
7	0 52 39.62	+4.48	+7 47 38.3	+27.1	*A. G. Leipzig II* 320.

NOTES

Comet was at all times very diffuse and without a well defined nucleus. All the observations of the comet were made by direct micrometer measures of Δα and Δδ. All observations and star connections have been corrected for differential refraction.

AN ANNUAL TERM IN RIGHT ASCENSION,

By R. MELDRUM STEWART.

In two recent papers* M. L. ZIMMER has drawn attention to the difference in clock corrections from evening and morning observations, and the consequent discordance between fundamental right ascensions of the same star determined at intervals of six months; he adds the suggestion that, though contrary to our present ideas of the magnitude of parallax, the only apparent explanation of the phenomenon is a parallactic effect.

It does not seem clear, however, that his results can be explained on this hypothesis, since the parallax in right-ascension varies with the secant of the declination, while the observed differences show no such variation, as may readily be seen from the following tabulation of the mean Δ's for the different zones of declination —

δ	Δ	δ	Δ
+30° to +20°	ˢ.038	−20° to −30°	ˢ.040
+20 to +10	.048	−30 to −40	.038
+10 to 0	.053	−40 to −50	.042
0 to −10	.040	−50 to −71	.042
−10 to −20	.042		

The figures used have been taken from the more extensive data of the first paper; the mean of all the

* *Astron. Jour.* Nos. 745 and 766.

Δ's is $^s.042$; that for the 6-hour group given in the second paper is $^s.044$.

A part of the differences between individual stars may no doubt be due to parallax, since this, when measurable, necessarily enters the Δ's with practically its full value; unless, however, the above figures should be materially altered by the inclusion of additional data, the explanation of the general effect on the hypothesis of parallax appears to be definitely excluded. A similar objection exists to PROF. TUCKER's suggestion* that the cause lies in lateral refraction, since the effect of this also, when expressed as a correction to right ascensions, would vary with the secant of the declination, except as modified by a possible zenith distance effect.

If it should prove, as appears from the present somewhat limited data, that the effect is really independent of the declination, the explanation must evidently lie in some diurnal fluctuation which affects the observed time of transit of all stars alike, and which acts similarly to a diurnal change in clock-rate, though apparently too regularly to be attributable to this cause. It constitutes a very real problem, whose solution, as MR. ZIMMER remarks, is essential to the satisfactory progress of fundamental astronomy. It appears desirable to find definitely according to what law it depends on the *sun's* hour-angle; also whether it depends at all on the season (that is, on the *sun's* declination) and on the latitude of the place of observation; for the latter the co-operation of different observatories would of course be essential.

Dominion Observatory, Ottawa,
April 21, 1920.

* *L. O. B.* 323.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A $4\frac{1}{2}$ INCH REFRACTOR,

BY A. W. QUIMBY.

1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Jan. 1	12	–	1	56	1	fair	Feb. 12	8	–	2	10		poor	Mar. 17	7	–	1	46	1	fair
2	8	–	1	45	1	fair	13	12	3	5	32	1	fair	18	7		1	50	1	fair
3	8	–	1	70	1	fair	14	9	2	7	54	2	fair	20	8	1	2	56	1	poor
4	8	1	2	38	2	fair	15	9		6	36	3	poor	21	8	1	3	106	2	fair
5	8		1	32	2	fair	16	4	–	6	32	3	fair	22	7	–	3	149	2	fair
6	8	–	1	13	2	fair	17	9	1	7	11	3	fair	23	7	–	3	175	2	fair
7	11	–	1	3		poor	18	8	1	8	20	3	fair	24	7	1	2	108	3	fair
10	8	2	3	10	2	fair	19	4	–	8	20	3	fair	25	7	–	2	76	2	fair
12	8	1	3	8		poor	20	8	–	6	19	2	fair	26	3	1	3	43	2	fair
13	8	–	3	8		poor	21	8	–	6	21	1	fair	27	7	–	2	12	1	fair
14	8		3	10	2	fair	22	4	2	7	32	3	fair	28	7	–	2	2	1	fair
15	8	–	3	12	2	fair	24	8	–	6	6	2	poor	29	3	–	1	1	1	fair
17	8		3	6	1	fair	25	7		1	1		v.p.	30	7	1	2	2	1	fair
18	8	2	5	8	4	fair	26	8	1	2	20	3	fair	31	7		2	2	2	fair
20	9	–	4	5	2	fair	27	8		2	16	2	fair	Apr. 1	3		2	2	1	fair
25	9	1	2	80	–	poor	28	8		1	13	2	fair	2	3		1	1		poor
27	8	–	2	80	1	fair	29	1		1	10	1	poor	3	7		1	1	2	fair
28	9	–	2	90	1	poor	Mar. 1	8	–	1	5	1	poor	5	7	–	–	–	–	fair
29	9		2	72	2	poor	2	8	–	1	5	2	fair	6	7	–	–	–	2	fair
30	8	–	1	41	1	poor	3	8		1	4	1	fair	7	9					fair
31	8	–	1	21	2	poor	4	8	–	1	3	1	fair	8	7	–	–	–		fair
Feb. 1	8		1	13	2	poor	6	8	1	1	2	1	fair	9	7			–	–	fair
2	1				–	poor	7	1	1	1	2	7	poor	10	5	1	1	1	1	fair
3	1	–	–	–		poor	8	8	1	3	29	1	fair	11	7		1	1	1	fair
6	2	–	–	–	–	poor	9	8	–	3	36	1	fair	12	7		1	1	1	fair
7	8	1	1	15	1	fair	10	8	–	3	12	1	fair	13	5	1	2	3	1	fair
8	12	1	2	20	1	fair	11	8	1	4	46	3	fair	14	5	–	2	6	1	fair
9	8	–	2	20	1	fair	12	3	–	4	34	2	fair	15	7		2	6	1	fair
10	4	1	3	15	1	fair	14	4	–	1	1	1	fair	16	10	–	2	2	–	poor
11	10	3	5	15	4	fair	15	7	1	1	1	1	fair	18	7	–	2	2	–	fair

1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Apr. 19	7		2	2		fair	May 14	12	–	2	4	–	fair	June 8	7	–	2	6	2	fair
20	7	–	1	1	–	fair	15	6	–	1	4	1	fair	9	6	1	3	16	2	fair
21	7	–	1	1	–	fair	16	7	–	–	–	1	fair	10	5	–	2	20	1	good
22	7		1	1	1	fair	17	7	1	1	1	2	fair	11	7	–	1	10	1	fair
23	7			–	1	fair	18	7	–	1	2	2	fair	12	6	–	1	17	1	good
24	7			–	1	fair	19	7	–	1	1	–	poor	13	10	–	1	10	1	poor
25	7	1	1	1	1	fair	20	7	–	1	1	–	fair	14	6	1	2	14	3	fair
26	7	–	1	1	1	fair	21	7	–	1	1	–	fair	15	7	–	2	17	3	fair
28	5	1	2	4	1	fair	22	7	1	2	2	1	fair	16	7		2	10	2	fair
29	7	–	2	6	2	fair	23	12		2	5	1	fair	17	7	1	3	3	1	poor
30	7		2	5		fair	24	12	–	1	4		poor	18	5		2	3	2	fair
May 1	6	1	2	3	–	fair	25	9		1	4	–	poor	19	7	–	2	4	1	fair
2	7	1	3	6	2	fair	26	5	2	2	21	1	fair	20	7	–	2	8	1	fair
3	7	1	4	11	2	fair	27	7	1	4	24	1	fair	21	6	1	3	6	1	fair
4	7	2	3	6	1	fair	28	7		3	21	1	fair	22	7	–	3	8	1	fair
5	7	2	4	8	2	fair	29	6	–	3	21	1	fair	23	7	–	3	8	1	fair
6	7	–	4	6	2	fair	30	6	2	5	25	3	fair	24	7	1	4	16	2	fair
7	3	1	4	18	2	fair	31	7	–	5	18	2	fair	25	6	1	5	12	2	fair
8	7	–	3	11	1	fair	June 1	6	–	4	25	3	fair	26	7	–	4	8	2	fair
9	5	1	4	21	3	fair	2	6	–	4	22	3	fair	27	7	1	4	8	4	fair
10	7		4	18	3	fair	3	6		3	16	2	fair	28	6	1	4	12	5	fair
11	7	–	3	8	1	fair	4	1	–	1	16		poor	29	7	–	4	10	3	fair
12	7	–	3	8	1	fair	6	7	–	2	3	1	fair	30	4	–	3	18	2	fair
13	12	–	2	2	–	poor	7	7	1	2	4	2	fair							

OBSERVATIONS OF THE ECLIPSE OF THE *SUN*, DEC. 3, 1918,

By BERNHARD H. DAWSON.

On two plates obtained during the annular phase and one a few seconds after third contact, the following differential coördinates, *Moon* − *Sun*, were deduced:

1918	G. M. T.	$(\alpha - a)\cos\delta$	$(\delta - \delta)$
d	h m s	$''$	$''$
Dec. 3	3 7 59.9	−25.46	−36.26
	3 10 49.4	+23.23	−44.53
	3 11 59.2	+39.90	−43.64

The coördinates of the telescope with which the plates were obtained are:

$$\lambda = +57^{\circ}\ 56'\ 9''.9$$
$$\varphi = -34\ \ 54\ \ 31\ .5$$
$$\varphi' = -34\ \ 43\ \ 42\ .3$$
$$\log\rho = 9.999\,526$$

A comparison of the observed differential coördinates with values deduced from the Elements given on page 559 of the *American Ephemeris* leads to the indicated corrections to the geocentric place of the *Moon* and of the axis of the shadow:

$$\cos\delta\,\Delta\alpha = +3''.35 \pm 0''.93 \qquad \Delta x = +0.00101$$
$$\Delta\delta = -3\ .80 \pm 1\ .06 \qquad \Delta y = -0.00115$$

Owing to clouds it was impossible to observe any contacts except the third, and that was not obtained accurately. It is, however, in substantial agreement with the corrections above deduced.

Details of the measures and reductions will be published in a future volume of the *Publicaciones del Observatorio de La Plata*, and will be communicated on request.

La Plata, April, 1920.

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ON THE ORIGIN OF PERIODIC COMETS,

By HENRY NORRIS RUSSELL

It is well known that certain short period comets have been diverted into their present orbits by close encounters with *Jupiter*, previous to which their periods were much longer than at present; and for this reason the numerous comets with periods between five and nine years are often described as belonging to *Jupiter's* "family." It is also generally supposed that the comets of somewhat longer period belong, in the same sense, to the "families" of *Saturn*, *Uranus* and *Neptune*. Strong evidence against the real existence of *Neptune's* family has however been presented by H. C. Wilson (1).

It is the purpose of the present discussion to examine the validity of the common supposition as regards captures by the outer planets, and to extend the results to comets of still longer period.

I — Theory

The theory of the capture of comets by planets has been extensively studied, notably by H. A. Newton (1a) from whose discussion the following results may be quoted:

(*a*) It is possible that an originally parabolic orbit may be transformed by a single encounter with any one of the major planets into an elliptic orbit with period shorter than that of the planet, and even that the comet may be stopped dead, so that it falls into the *Sun*.

(*b*) Such great perturbations will occur only when the encounter is very close, so that they will be rare, and for every case in which they happen, there will be a much larger number in which the perturbations are smaller, and the period after the encounter is longer.

Newton calculates that, out of 10^9 comets which enter a sphere described about the *Sun*, with radius equal that of *Jupiter's* orbit (assumed circular) the number which have their orbits changed into ellipses with a period less than half that of *Jupiter* should be 126. Those with periods less than *Jupiter's* should number 839: with periods less than twice *Jupiter's* 2670: and so on.

(*c*) Of the captured comets the majority will be moving in direct orbits. Newton calculates that out of the 839 comets with period less than *Jupiter's* 257 should have inclinations less than 30°, and only 51 inclinations exceeding 150°. Moreover, those with direct motions are much more likely to have their periods still further shortened at a subsequent encounter than to have them lengthened, while the reverse is the case for the comets with retrograde motion.

(*d*) Finally, and obviously, the orbits of the captured comets will continue to pass near to those of the capturing planet, until they are gradually shifted to a greater distance by the cumulative effect of planetary perturbations of the ordinary type. Further close encounters with the original capturing planet, or with some other planet, may be excluded from this statement, if we agree to assign a comet to the family of the planet which it last encounters. The probability of such additional encounters, however, is enormously greater for a captured comet than for one moving at random, and encounters with a second planet are possible if the inclination of the orbit is small after capture. These factors, as Newton shows, may operate to cause a very considerable increase in the number of comets with short period, direct motion, and small inclinations.

Certain other results, not expressly stated by Newton, but following from his equations, may be mentioned.

(*e*) Newton proved that, if a planet of mass m moves in a circular orbit of radius r, and a very large number of comets, moving at random in parabolic orbits, approach the *Sun* within the distance r, the fraction F of the whole number which will have their

orbits changed, by a single encounter with the planet, into ellipses of mean distances less than A will be

$$F = \frac{m^2}{4r^2}\int\left[4a^2 - \left(\frac{a - r - as^2}{s}\right)^2\right]ds \qquad (1)$$

where the range of integration extends over all values of s greater than $\sqrt{2} - 1$, which make the integrand positive. If in this expression we set

$$a - r = (\lambda^2 - 1)a,$$

the limits of integration are $1 - \lambda$ and $1 + \lambda$ provided that $\lambda < 2 - \sqrt{2}$, but are $\sqrt{2} - 1$ and $1 + \lambda$ if λ exceeds this limit. In the former case

$$F = \frac{4}{3}\frac{m^2a^2}{r^2}\lambda^3 \qquad (2)$$

and in the latter

$$F = \frac{m^2a^2}{r^2}\left(-\frac{1+\sqrt{2}}{4}\lambda^4 + \frac{2}{3}\lambda^3 + \lambda - \frac{\sqrt{2}-1}{3}\right) \qquad (3)$$

These equations, though not given expressly by NEWTON, must have been used by him in deriving the results given under (b) above.

When a is considerably greater than R the factor in parenthesis in (3) may be expanded in a series

$$\frac{4}{3} - \frac{2+\sqrt{2}}{8}\frac{r^2}{a^2} + \frac{\sqrt{2}}{96}\frac{r^3}{a^3} \ldots$$

which is so rapidly convergent that for all practical purposes we may write

$$F = \frac{4}{3}\frac{m^2a^2}{r^2}$$

whenever $a > 3r$.

The number of comets available for capture is, however, greater for the remoter planets. NEWTON shows that, if the comets are moving at random in parabolic orbits, the number which enter a sphere of radius r, described about the *Sun* as centre, per unit of time will be proportional to r — from which it follows that the fraction of this whole number which have perihelion distances less than q will be $\frac{q}{r}$. Hence the whole number of comets which during a given interval of time, are diverted by a given planet into elliptic orbits of mean distance less than a is $\frac{4}{3}\frac{m^2a^2}{r}$ times the number which approach the *Sun* within the unit of distance during this interval. But many of these captured comets will have large perihelion distances, and escape observation. If we assume that the same fraction of them have perihelion distances less than q as in the case of the original parabolic comets, (which should be nearly true in the majority of cases, where the perturbations are small) we find, for the number of captured comets which will have mean distances less than a and perihelion distances less than q the fraction $\frac{4}{3}\frac{m^2a^2q}{r^2}$ of all those which enter the unit-sphere. This expression holds good when a is large compared with r; but, if q is small compared with r it remains a good approximation for smaller values of a, — the decrease in the coefficient F, which is $\frac{4}{3}$ when a is large, being compensated by the concentration of the perihelion distances toward small values which necessarily occurs when a is less than r.

If we set $q = 2$, corresponding roughly to the limit beyond which comets are likely to escape observation, and $a = 100$, we find that, out of 100,000,000 comets which enter a sphere, described about the *Sun* of radius equal to the *Earth's* mean distance, the number which are changed by capture into comets visible from the *Earth*, and of period less than 1000 years, by the action of *Jupiter* will be 90,000; by *Saturn* 2400; by *Uranus* 14; and by *Neptune* 8.

If the limiting period is made shorter, the relative predominance of *Jupiter* will be still greater.

(f) The effects of an individual encounter are given by the equations

$$\frac{1}{a''} = \frac{1}{a'} + \frac{1}{a} \quad (4) \qquad a = \frac{s}{4m}\frac{A^2 + d^2 + h^2\sin^2\theta}{A\cos\theta + h\sin^2\theta} \quad (5)$$

In (4) a' and a'' are the comet's mean distances before and after the encounter. If the original orbit is parabolic, the mean distance after the encounter is a. In equation (5) d is the least distance between the planet's orbit and the undisturbed orbit of the comet; s the ratio of the undisturbed velocity of the comet, relative to the planet, to that of the planet, relative to the *Sun*; θ the angle between these two velocity vectors; h the distance which the planet has still to go to reach the point on its orbit which is nearest the comet's undisturbed orbit at the instant when the comet, if undisturbed, would reach the point on its own orbit which is nearest the planet's orbit; and A the real semi-axis of the hyperbolic orbit which the comet describes about the planet during the encounter.

These equations have been derived by NEWTON with the usual approximations, (neglecting the perturbations of the comet by the planet when it is

remote from the latter, and by the *Sun* when it is near the planet) but are correct to the first order of small quantities, and applicable to all encounters, whatever the eccentricity of the planet's orbit. If the latter is circular, and of radius a_1, then $A = \frac{m\,a_1}{s^2}$; in the more general case, if r is the distance of the planet from the *Sun* at the time of the encounter, and a_1 its mean distance

$$A = \frac{m\,a_1\,r}{s^2\,(2a_1 - r)} \tag{6}$$

If the orbit along which the comet approaches the planet is given, all the quantities which appear in (5) are fixed with exception of h, which defines the circumstances of the encounter, and may be so determined as to make the perturbation a maximum.

The condition for this is readily found to be

$$h = \frac{A^2 + d^2}{A\cos\theta \pm \sqrt{A^2 + d^2\sin^2\theta}}$$

which gives

$$a = \frac{s}{2m}\,\frac{A^2 + d^2}{A\cos\theta \pm \sqrt{A^2 + d^2\sin^2\theta}} \tag{7}$$

The positive sign of the radical corresponds to the maximum perturbation in the direction of the ellipse, and negative sign to the maximum in the direction of the hyperbola.

It follows from (6) that A is of the order of magnitude of ma_1, and this quantity is very small. Hence unless the distance between the orbits is very small, we may neglect A in comparison with d, and write

$$a = \frac{s\,d}{2m\sin\theta} \tag{8}$$

(g) It is of interest to determine how near to the planet a comet must approach, in order to be diverted from a parabolic orbit into one of mean distance a. If α is the acute angle between one of the asymptotes of the hyperbolic orbit of the comet about the planet and the line of apsides, p the perpendicular distance of the planet from the asymptote, and q the distance at pericentre, then, as NEWTON shows,

$$p^2 = d^2 + h^2\sin^2\theta,$$
$$p = A\tan\alpha,$$
$$q = A\,(\sec\alpha - 1).$$

If now we set $d = p\sin\psi$, $h\sin\theta = p\cos\psi$, (5) becomes

$$a = \frac{sA}{4m}\,\frac{\sec^2\alpha}{\cos\theta + \tan\alpha\sin\theta\cos\psi}$$

For the present purpose we may treat the planet's orbit as circular, and set

$$A = \frac{ma_1}{s^2}$$

We then find

$$\frac{q}{a^2} = \frac{16m}{a_1}$$

$$\cos\alpha\,(1 - \cos\alpha)\,(\cos\alpha\cos\theta + \sin\alpha\sin\theta\cos\psi)^2$$

The last factor is this expression is a maximum, and equal to unity when $\psi = 0$ and $\theta = \alpha$. The maximum value of $\cos\alpha_1(1 - \cos\alpha)$ is $\frac{1}{4}$ when $\alpha = 60°$. Hence we have

$$q \leq \frac{4m\,a^2}{a_1} \tag{9}$$

At the limit when $a = \frac{1}{2}a_1$ we have $q \leq ma_1$. NEWTON shows that in this case (when the comet falls into the *Sun*) the actual value of q is $ma_1(\sqrt{2} - 1)$.

The corresponding distances in terms of the planets' equatorial radii are 4.3 for *Jupiter*, and 2.8 for *Saturn*, (or 1.25 times the outer radius of the rings,) 2.0 for *Uranus* and 3.6 for *Neptune*. Hence all the major planets may capture comets without colliding with them.

In the case of the *Earth*, $m = 3.0 \times 10^{-6}$ while the radius is 43×10^{-6} astronomical units. Hence a meteorite captured by the *Earth* which just escaped collision might have a mean distance as small as 1.9 and a period of 2.6 years. The probability of such an encounter, however, is negligibly small.

Summarizing the results of theory, we find that if the periodic comets owe their origin to capture by planetary perturbation from a great number of comets originally moving at random in parabolic orbits, they should show the following characteristics:

1. *Jupiter* should be responsible for almost all of the captures, *Saturn* accounting for only one comet in forty, and *Uranus* and *Neptune* together for only one in four thousand.

2. Of the comets which owe their present orbits to a single encounter, the number with mean dis-

tances less than a should be proportional to a^2 — or the number of periods less than P to $P^{\frac{4}{3}}$. The number of comets with periods less than P which come to perihelion within a given short interval should therefore be proportional to the cube root of the period. Subsequent encounters tend to increase the relative proportions of short periods.

3. The comets of short period should show a preponderance of direct motions and small inclinations, which is likely to be very pronounced when the effects of subsequent encounters are considered. Those of long period, for most of which the perturbations have been relatively small, should exhibit nearly a random distribution of their orbit planes.

4. The orbit of every captured comet should pass close to that of the planet which last captured it. The remoter the date of capture, the more the original minimum distance is likely to have been increased by the accumulation of ordinary perturbations, but, even in such a case, there should be many more comets passing near the planet's orbit, and correspondingly few which never approach it closely, than in the case of a random distribution.

II — Observational Data

The observed characteristics of the orbits of those comets for which periods of less than 2000 years have been computed are summarized in Tables I and II. The data are taken from the table of elements of periodic comets in the Appendix in the *Connaissance des Temps* for 1915, except when otherwise noticed.

The first column gives the designation of the comet, — comets which have been observed at more than one return being distinguished by the names of their discoverers, and those seen only once by the year of apparition. The second column gives the period, the third and fourth the perihelion and aphelion distances, and the fifth the inclination of the orbit to the ecliptic. These are usually taken from the definitive elements, and represent the osculating orbit near perihelion. The uncertainty of the longer periods and the corresponding aphelion distances is usually considerable. The most doubtful cases are indicated as usual by a colon. For a few of the latest comets the elements are not definitive, but are based on long enough observed arcs to give reliable results.

The last column of Table I gives the minimum distance between the orbit of each of the short-period comets and *Jupiter's* orbit. In Table II, which deals with the comets of longer period, there are four corresponding columns, giving the minimum distances from the orbits of the four major planets. The tabular quantities, strictly speaking, represent the minimum of the distance between any point on the

Table I — Short-Period Comets

Comet	Period	q	$2a-q$	i °	Least Distance d from *Jupiter*
Encke	3.30	0.34	4.09	12.6	+0.92
1766 II	5.03:	0.40	5.46	8.0	−0.08:
1819 IV (2)	5.10:	0.89	5.03	9.0	+0.31:
Tempel₂	5.17	1.32	4.66	12.7	+0.63
1884 II	5.40	1.28	4.87	5.1	+0.55
1743 I (2)	5.43:	0.86	5.31	1.9	−0.02:
Brorsen	5.46	0.59	5.61	29.4	−0.14
1916 *a* (3)	5.50	1.34	4.89	10.7	+0.26
1886 IV	5.59	1.33	4.97	12.7	−0.02
1770 I	5.60	0.68	5.63	1.6	−0.00
Tempel-Swift	5.68	1.15	5.21	5.4	−0.58
1783	5.89:	1.46	5.06	45.1	+0.33:
Winnecke	5.89	0.97	5.55	18.3	+0.13
1915 *e* (3)	6.36	1.55	5.29	15.5	−0.08
1890 VII	6.37	1.82	5.05	12.8	−0.43
De Vico	6.40	1.67	5.22	3.6	+0.22
1909 IV	6.40	1.38	5.51	19.4	+0.12
Perrine	6.45	1.17	5.76	15.7	−0.09
Giacobini	6.51	0.98	6.00	29.9	+0.20
1892 V	6.52	1.43	5.55	31.3	+0.07
Tempel₁	6.54	2.09	4.90	10.8	−0.16
D'Arrest	6.54	1.27	5.72	15.8	+0.11
1896 V	6.55	1.45	5.55	11.4	−0.56
Kopff (4)	6.58	1.70	5.32	8.7	−0.04
1858 III	6.61	1.15	5.89	19.5	−0.07
Finlay	6.66	1.01	6.08	3.4	+0.01
1918 *d* (5)	6.68	1.89	5.21	5.6	+0.47
Biela	6.69	0.88	6.22	12.4	+0.42
Wolf	6.80	1.59	5.59	25.3	+0.05
Holmes	6.86	2.12	5.10	20.8	−0.36
Borrelly	6.93	1.40	5.87	30.4	−0.46
Brooks	7.10	1.96	5.43	6.1	−0.02
1895 II	7.20	1.30	6.15	3.0	−0.08
1894 I	7.42	1.15	6.46	5.5	−0.16
Faye	7.44	1.67	5.97	10.6	−0.10
1906 VI	7.59	1.63	6.09	14.5	+0.13
Schaumasse	8.07	1.23	6.82	17.7	−0.34
1881 V	8.69	0.73	7.72	6.9	+0.15
1889 VI	8.92	1.36	7.25	10.3	+0.65

comet's orbit and that point on the planet's orbit which has the same heliocentric longitude. This would be rigorously the least distance between any two points on the two orbits, if the planetary orbits were circular. The actual eccentricities of these orbits are so small that no sensible error is committed by this approximation, which saves much labor. The calculations were made with a slide-rule, except for a few cases of very close approach, when five-place logarithms were used.

The plus or minus sign is prefixed to these distances according as the comet at the point of nearest approach, is north or south of the planet. It must be borne in mind, however, that the line joining the nearest points of the two orbits is often very far from perpendicular to the plane of the planet's orbit, so that the distance from this plane to the point under consideration on the comet's orbit may be much less than the tabular quantity.

When the aphelion of the comet falls far inside the orbit of one of the outer planets the corresponding distance between the orbits is omitted in the table (or, in a few cases, placed in parentheses.)

Fayet[2] has published a discussion of the short-period comets, giving the minimum distances from *Jupiter's* orbit for all those known up to 1911. The values for the comets of period less than ten years, and observed at only one return, are taken from his paper, (except for these which have appeared since 1911). The corresponding data for the comets observed at more than one return had already been calculated when FAYET's paper came to the writer's attention. Comparison of the results shows that, when the same orbital elements are used, the difference between the values of the minimum distance obtained with the slide-rule and by FAYET's much more exact computations was 0.008 astronomical units, — which is considerably less than the variations in this distance

TABLE II — COMETS OF LONGER PERIOD

Comet	Period	q	$2a-d$	i	Least Distance d from *Jupiter*	*Saturn*	*Uranus*	*Neptune*
				°				
TUTTLE	12.1	1.03	9.5	55.0	−0.66	+2.15	......	.....
1846 VI	13.3	1.53	9.7	30.7	−1.17	+0.52	......	.....
1913 *c* (6)	17.6	1.53	12.0	14.8	+0.94	−0.71	......	.....
1866 I	33.2	0.98	19.7	162.7	+0.79	+0.45	−0.38	(10.8)
1867 I	40.1	1.58	21.8	18.2	+1.37	+1.49	−0.83	(8.5)
WESTPHAL	61.5	1.25	29.9	40.9	−0.36	−2.48	−7.0	−15.0
1827 II (7)	63.8	0.95	31.1	136.5	+1.32	+0.85	−1.00	− 4.9
PONS-BROOKS	71.6	0.77	33.7	74.0	−2.05	−1.69	+1.16	+ 5.4
BRORSEN-METCALF (8)	72.1	0.48	34.2	19.2	−0.48	−1.67	−3.86	− 7.7
OLBERS	72.7	1.20	33.6	44.6	−0.70	−3.39	−9.3	−16.4
1846 IV	75.7	0.66	35.1	85.1	+2.25	+1.84	−0.54	− 3.8
HALLEY	76.0	0.59	35.3	162.2	−0.77	−1.73	−4.7	− 7.8
1862 III	120.	0.96	47.6	113.6	+1.57	+0.80	−1.98	− 6.5
1889 III	128.	1.10	49.8	31.2	−0.33	−1.76	−5.8	−11.0
1917 *a* (9)	189.	0.19	65.7	32.6	−1.53	−2.96	−7.8	−14.8
1857 IV	235.	0.75	75.4	32.8	+1.87	+2.38	+3.5	+ 3.3
1855 II (10)	252.	0.56	79.3	156.9	+0.54	+0.48	−0.65	− 4.2
1885 III	275.	0.75	83.7	59.1	+0.21	−1.16	−6.2	−10.8
1905 III	297	1.12	87.8	40.2	−2.58	−3.23	−4.7	− 4.9
1874 IV	306	1.69	89.1	34.1	+1.71	+1.10	+0.030	− 3.2
1840 IV	367	1.48	101.1	58.0	+1.12	−0.60	−4.4	−11.0
1861 II	409	0.82	109.3	85.4	−1.40	−0.49	+2.4	+ 7.2
1861 I	415	0.92	110.4	79.8	−1.22	+0.11	+3.7	+ 8.6
1898 I	417	1.10	110.6	72.5	+0.57	−0.97	−6.4	−11.5
1793 II	422:	1.50	110.9	51.5	−0.59	−3.20	−8.7	−17.4

Comet	Period	q	$2a - q$	i	Least distance d from Jupiter	Saturn	Uranus	Neptune	$\Delta\beta$
1843 I	512:	0.006	128.0	144.3	−3.00	−5.02	−10.9	−16.8	−34
1846 VII	537	0.63	131.6	150.7	−1.52	−3.69	− 8.3	−13.1	−26
1906 VII (1)	583	1.21	138.5	84.8	+3.36	+4.00	+ 5.1	+ 4.3	+ 8
1811 II	755	1.58	164.2	31.3	−0.90	+0.14	+ 2.4	+ 4.9	+ 9
1886 V	771	0.27	167.9	87.7	−0.49	+0.020	+ 2.4	+ 5.0	+10
1882 II	772	0.008	168.6	142.0	−2.91	−5.01	−10.7	−16.6	−34
1853 III	782	0.91	168.9	122.2	−2.13	−1.83	− 1.05	+ 1.2	+ 2
1881 VIII	793	1.92	169.3	144.8	+0.39	−1.19	− 4.6	−10.6	−20
1854 V	994	1.36	197.9	14.2	+0.31	+1.47	+ 3.6	+ 6.5	+12
1887 II	999	1.63	198.3	104.3	+3.46*	+3.95	+ 3.8	+ 1.5	+ 3
1855 I	1059	2.20	205.6	128.7	−2.09	−0.70	+ 2.7	+ 7.5	+14
1854 IV	1089	0.80	210.7	40.9	−0.13	−1.80	− 5.7	−10.5	−20
1894 II	1143	0.98	217.6	87.0	−1.24	+0.18	+ 3.9	+ 8.9	+17
1853 I	1215:	1.09	226.7	159.8	+1.19	+3.03	+ 6.7	+10.4	+20
1785 II	1326:	0.43	240.8	92.6	−1.47	−3.73	−10.8	−17.6	−36
1807	1714	0.65	285.8	63.2	+2.92	+3.91	+ 5.0	+ 6.3	+12
1858 VI	1880	0.58	304.0	117.0	−1.10	−3.18	− 8.2	−15.3	−30

*Closest approach near comet's perihelion. A secondary approach at +3.89.

which may often be caused by perturbations during a single revolution of the comet.

III — Comparison of Observation with the Capture Theory

When the observational data are discussed statistically the familiar distinction between the "short period" comets and those of long period is conspicuous from the outset.

The distribution of the periods is shown in Table III in which the data have been extended, with the aid of the *Connaissance des Temps*, to a limiting period of 10,000 years; and the successive intervals correspond to equal increments of the cube root of the period, and hence, on the simple theory of capture, should contain equal numbers of comets.

For periods greater than ten years the numbers of comets in the successive intervals are roughly the same. The gradual falling off in the number of comets of very long period is doubtless due to the imperfection of the record, — many of these comets, having been regarded by computers as "parabolic." Apart from this, the differences in the numbers are probably no greater than might arise from chance among such small groups.

Table III. Distribution of Periods

Limiting Periods	Number of Comets
0	
10	39
80	12
270	5
640	11
1250	11
2160	5
3430	8
5120	5
7290	3
10000	6

The short-period comets, on the contrary are far more numerous than was to be anticipated on the theory of capture at a single encounter, and their periods are not uniformly distributed over the tabular interval, but clustered closely, — half of them lying with 0.5 years of their mean value, 6.39 years.

It is well known the distribution of the inclinations is radically different in the two groups, as is shown in Table IV. Every one of the comets with periods between 10 and 2,000 years has an inclination greater

Table IV. Distribution of Inclinations

Short Periods		Longer Periods	
0° to 10°	14	0° to 30°	1
10 to 20	18	30 to 60	14
20 to 30	4	60 to 90	9
30 to 40	2	90 to 120	4
40 to 50	1	120 to 150	6
		150 to 180	5
Total	39	Total	42
Mean Inclination 13°.9		Mean Inclination 88°.1	

than the mean inclination of the short-period comets. The greatest inclination for any short-period comet is 45°, and two-thirds of the comets of longer period have inclinations exceeding this. Dividing the latter group into two equal parts, it appears that of the first half, with periods less than 100 years, 16 are moving direct and 5 retrograde, and the mean inclination is 66°.8, while out of these comets having periods from 400 to 2000 years, 11 are moving direct and 10 retrograde, and the mean inclination is 97°.5. Both with regard to period and inclination, therefore, the distribution of the comets of longer period is very much what might be expected as a result of capture by single encounters. That of the comets of short period is glaringly different, and indicates that they owe their present orbits to the cumulative effect of perturbations at successive encounters with *Jupiter* (as has been maintained by Newton) while their large number suggests that disruptive tidal forces at the time of encounter have broken up the original comets into much more numerous fragments. The theory of such disintegration has been worked out by Callandreau (12), and Fayet (13) has pointed out several groups of comets which may thus have had a common origin. These investigations, — to which the present discussion adds very little — confirm the general belief that the comets with periods less than ten years belong to *Jupiter's* "family." The mean period of these comets is 0.54 times the period of *Jupiter*, and their mean aphelion distance (5.55) is 1.07 times *Jupiter's* mean distance.

Are similar families to be found among the comets of longer period? Superficially, the evidence for their existence seems very favorable. The comets with periods between ten and one hundred years show a rather conspicuous division into three groups, comprising respectively three, two and seven members, with mean periods of 14.3, 36.6 and 70.5 years, and mean aphelion distances of 10.4, 20.8 and 33.3 astronomical units. These periods are respectively 0.49, 0.44 and 0.43 times the periods of *Saturn*, *Uranus* and *Neptune*, while the aphelion distances are 1.09, 1.08 and 1.11 times the mean distances of the three planets (as against 1.07 for *Jupiter's* undoubted family). It is therefore generally believed that these three groups of comets have actually been diverted into their present orbits by encounter with *Saturn*, *Uranus* and *Neptune*.

Among the comets of still longer period there are two conspicuous groups with mean periods of 406 and 775 years, and another, less sharply defined, near 270 years. May these perhaps be the families of undiscovered remoter planets?

Little attention appears to have been given to the fact that the true criterion for detecting a captured comet is not that its aphelion distance shall be but little greater than that of the capturing planet, but that its orbit shall pass close to the planet's orbit. The former result is attained only in the rare cases when the perturbations are exceptionally great, — or cumulative in the same direction at several encounters; but the latter happens in every case of "capture" whether the resulting period is short or long, — and, indeed, even if the orbit is rendered hyperbolic.

Upon applying this test to the data of Table II it is found that two out of the three comets of "*Saturn's* family" pass fairly near the orbit of the planet; the two which are assigned to *Uranus* come pretty close to his orbit; but not one of the seven members of "*Neptune's* family" can come nearer to him than 3.8 astronomical units, while all of them may come closer than this to *Saturn* and much closer to *Jupiter*.

The reality of this — the largest of the supposed families — is thus rendered very doubtful. This seems to have been first pointed out by Crommelin, (14) in the case of Halley's Comet, while W. H. Pickering (15) observed that the same difficulty occurred in the case of the other members of the group, and Wilson (1) showed that most of them might better be assigned to other planets than *Neptune*.

Extending the study to all comets with periods less than 2000 years, the circumstances of possible approach to the major planets are as summarized in Table V. The number of cases in which the ratio of the least distance d between the present orbits of the planet and comet to the mean distance a of the planet lies between specified limits is tabulated, separating the cases where the comet passes north and south of the planet. The last column for each planet gives the number of approaches within the given limits of distance which might be expected theoretically under the assumptions explained below. The whole number of approaches is less for the outer planets, since the

Table V — Approaches to Planets

Ratio $\frac{d}{a}$	North	South	All	Theory
Jupiter				
0.0 to 0.1	3	5	8	8
0.1 to 0.2	4	5	9	8
0.2 to 0.3	6	6	12	7
0.3 to 0.4	3	1	4	6
0.4 to 0.5	1	3	4	6
0.5 to 0.6	0	3	3	4
0.6 to 0.7	2	0	2	3
All	19	23	42	42
Saturn				
0.0 to 0.1	9	4	13	8
0.1 to 0.2	4	9	13	7
0.2 to 0.3	2	1	3	7
0.3 to 0.4	1	7	8	6
0.4 to 0.5	3	0	3	6
0.5 to 0.6	0	2	2	3
Over 0.6	0	0	0	5
All	19	23	42	42
Uranus				
0.0 to 0.1	2	6	8	7
0.1 to 0.2	8	1	9	7
0.2 to 0.3	3	6	9	5
0.3 to 0.4	1	4	5	5
0.4 to 0.5	0	4	4	4
0.5 to 0.6	0	4	4	3
Over 0.6	0	0	0	8
All	14	25	39	39
Neptune				
0.0 to 0.1	2	1	3	7
0.1 to 0.2	5	4	9	6
0.2 to 0.3	6	3	9	4
0.3 to 0.4	1	7	8	4
0.4 to 0.5	0	2	2	3
0.5 to 0.6	0	6	6	3
Over 0.6	0	0	0	10
All	14	23	37	37
Short-Period Comets and *Jupiter*				
0.0 to 0.05	10	14	24	
0.05 to 0.10	5	4	9	
0.10 to 0.15	3	2	5	..
0.15 to 0.20	1	0	1	
All	19	20	39	..

aphelia of a few of the comets do not reach to their orbits.

The short-period comets are tabulated separately. They show the well-known tendency toward close encounters with *Jupiter* — 85 per cent. of them being capable of approaching the planet within one-tenth of its distance from the *Sun*. The only case in which the distance of closest approach exceeds one-eighth of *Jupiter's* mean distance is that of Encke's Comet, — which is exceptional in many ways, and is subject to a retarding force, which must have diminished the size of its orbit.

Of the comets of longer period, however, only twenty per cent. can ever approach *Jupiter* with one-tenth of its distance from the *Sun* (provided that their present orbits remain unaltered). The corresponding percentage is 31 for *Saturn*, 20 for *Uranus*, and only 8 for *Neptune*. Now it is obvious that, even if the comets' orbits were distributed quite at random, a certain fraction of them should, merely by chance, pass fairly close to the orbits of the planets. The probability that the minimum distance between the orbits of the comet and planet should be less than a given fraction of the planet's mean distance would be difficult to evaluate rigorously: but an approximation, good enough for the present purpose, can easily be obtained. Treat the planet's orbit as circular, and consider the points A and B at which the comet's orbit cuts the sphere described about the *Sun* as centre, with radius equal to the distance of the planet. Let A be that one of these two points which is nearest the planet's orbit: then the least distance between the orbit of the comet and planet will in general be less than the distance of A from the planet's orbit. If a straight line is drawn, joining A to the *Sun*, the least distance between this line and the planet's orbit, will sometimes be less than the corresponding distance for the comet's orbit, and sometimes greater, depending on the curvature and orientation in space of the latter; but the two will usually be very nearly equal, and the line may be substituted for the orbit, with accuracy enough for the present purpose.

But the minimum distance between the planet's orbit and this line is obviously equal to the perpendicular distance of the point A from the plane of the planet's orbit. If the point A lay at random on the sphere, the probability that its distance from the given diametral plane shall be less than x times the radius of the sphere is well known to be simply x. But A has been defined as the nearer one to this plane of the two points A and B, and the desired probability is therefore the probability that at least one of the points A and B shall be within the distance x from the

diametral plane, (taking the radius as unit). If the two points were placed at random, and independently on the sphere, this probability would be $2x - x^2$. This gives an expectation of 19 per cent for $x = 0.10$, while the mean of the observed frequency for the four major planets is 20 per cent. But the assumption that A and B are distributed independently over the sphere is incorrect in the case of the actual comets, for the conditions of observation limit our study to orbits of relatively small perihelion distance, and this means that the distance separating the points A and B will be small in comparison to the radius of the sphere on which they lie, provided that the latter is considerable. Let the arc AB upon the sphere be denoted by $2C$. The values of this quantity for each comet and all the planets may be immediately derived from the values of the true anomaly at the time of closest approach, which had already been computed. For the same planet, and different comets, they vary considerably, being least when the perihelion distance is smallest, but the dispersion about the mean value is not great. For example, in the case of *Jupiter*, the mean value of C is 47°, and half of the individual values are within 8° of this. The mean value of C for *Saturn* is 32°.3; for *Uranus* 21°.3; for *Neptune* 14°.6.

A very good approximation to the actual probability may be obtained by assuming that, in the case of each planet, the arc AB is the same for all comets, and equal to twice the mean value of C. Consider therefore, two points, A and B, on the sphere, at a fixed distance $2C$ apart, but otherwise lying at random. If A is within the distance x from the fixed diametral plane, it will be within a distance θ from the corresponding great circle on the sphere, (when $x = \sin\theta$). The pole P of this great circle must be within the distance θ from the great circle which has A as its pole, — that is within a certain zone of width 2θ, girdling the sphere. If B is within the distance x from the diametral plane, P must be within a similar zone, which follows the great circle having B as its pole. The central lines of these two zones cut at an angle $2C$. If P lies anywhere within either of them, one or other of the points A and B will be at a distance less than x from the diametral plane. The probability of this occurrence is equal to the ratio of the area of the sphere occupied by the two zones together (counting the part common to the two only once) to the area of the whole sphere. This ratio may be calculated without difficulty. As the results may be of use in other problems they are given in Table VI, in which the tabular quantity is the probability that the distance of at least one of two points, A and B, on a unit sphere, separated by a distance $2C$, shall be within the perpendicular distance x from a fixed diametral plane.

TABLE VI

x	$C = 45°$	32°.5	15°	0°
0.0	0.000	0.000	0.000	0.000
0.1	0.194	0.195	0.186	0.100
0.2	0.374	0.369	0.346	0.200
0.3	0.540	0.535	0.459	0.300
0.4	0.693	0.678	0.554	0.400
0.5	0.824	0.800	0.644	0.500
0.6	0.932	0.879	0.732	0.600
0.7	0.996	0.945	0.818	0.700
0.8	1.000	0.990	0.898	0.800
0.9	1.000	1.000	0.969	0.900
1.0	1.000	1.000	1.000	1.000

The tabular values of C are chosen as to correspond approximately to the cases of *Jupiter*, *Saturn* and *Neptune*. The probability for other values of C may be found by graphical interpolation.

With the aid of this table, the number of cases of approach within the limits given in Table V which might be expected from chance alone, has been computed, and is given in the last column for each planet. Upon comparing these with the observed distribution it is evident that there is little left to be explained, especially when it is considered that among so small a number of cases the observed distribution will inevitably be rather ragged. There is apparently a slight excess of comets passing close to *Saturn*; but this is balanced by a deficiency of those coming near to *Neptune*. For the four major planets together the number of possible approaches within one-tenth of the planet's mean distance is 32, while 30 might be expected if the comets' orbits lay at random. The only serious difference between the theoretical and actual distribution is a lack of comets which pass very far from the planets. There are in all only two cases in which $\frac{d}{a}$ exceeds 0.6, as against 26 cases predicted.

This discrepancy can be largely, if not wholly, explained. In the first place the curvature of the comet's orbit between the point A and the perihelion, which was neglected above, will clearly have a greater influence the farther A is from the planet's orbit, and will tend on the whole to diminish the distance of closest approach, so that the approximate theory will therefore exaggerate the number of cases in which this distance is great. Secondly, it is noteworthy that most of the comets which pass far from the planets' orbits go to the south of them, especially in

the cases of *Uranus*, and *Neptune*, where every comet for which $\frac{d}{a}$ exceeds 0.35 passes to the southward.

It is probable that this singular fact has no cosmical significance, but is merely a result of the situation of most astronomers in the northern hemisphere of the earth. As HOLETSCHEK (16) has pointed out, comets which are north of the *Sun* at perihelion are more likely to be discovered, — and, if discovered, to be observed long enough to permit the calculation of an elliptic orbit, — than those whose perihelia are south of it, (unless the perihelion distance is small). This observational preference results in a predominance of southern latitudes among the aphelia, and to a nearly equal degree, of southern latitudes when the comet is at the distance of the remoter planets. There is therefore good reason to believe that, if observation in the *Earth's* southern hemisphere had been as assiduous as in the northern, our list of periodic comets would be extended by the addition of members with southern perihelia and high northern latitudes when remote from the *Sun* — thus increasing the number of comets whose orbits pass far from the planets to something more like the theoretical expectation. There may, however, be, after these allowances are made, a real deficiency of periodic comets whose aphelia are near the poles of the ecliptic.

Of much more importance for the present purpose, however, is the small excess of comets whose orbits pass close to those of the major planets above the number which might be expected to do so by accident. There can clearly be very few cases of real capture. The most promising ones are the closest approaches: and in these instances it is worth while to compute by NEWTON'S formula what is the greatest alteration in the comet's mean distance which could be produced by a single encounter with the planet under the most favorable circumstances. The appropriate equations are (4), (6) and (7) of Part I and the necessary data and results are given in Table VII. In computing the direction θ, and magnitude S, of the velocity of the comet, relative to the planet, the eccentricity of the planet's orbit was taken into account. Two values of a (the reciprocal of the perturbation of the comet's mean distance) are given, corresponding to the maximum acceleration and retardation of its velocity. The last four columns give the present mean distance and period of the comet, and the periods which it would have after maximum perturbation in either direction. The last comet, which comes nearer to *Neptune* than any other, is inserted to show how insignificant the perturbations are when distance of approach is considerable. It appears, therefore, that there are only two of the 42 comets which, if following their present orbits, could be "released" (that is, directed into sensibly parabolic orbits) by future encounters, — one with *Jupiter* and one with *Saturn*. In the other cases, the maximum possible change in the period by a single encounter is at most little greater than the uncertainty in the determination of the period itself from the observations of a single apparition, (the only exception being Comet 1861 I, which was unusually well observed).

The other forty comets certainly do not owe the present forms of their orbits directly to capture. Several alternative ways of accounting for the phenomena are open:

(1) They may have been "captured" from sensibly parabolic orbits at some times in the past, and had their orbits further modified by planetary perturbations of the ordinary type so that they no longer pass near the original point of encounter. This suggestion has been made by W. H. PICKERING (17) who, however, attributed the principal perturbation to the action of a hypothetical distant planet of great mass, revolving in an orbit highly inclined to the ecliptic.

TABLE VII — PERTURBATIONS AT CLOSEST APPROACHES

Comet	Planet	d	s	θ	A	a		Present Mean Dist.	Present Period Yrs.	Period after Perturbation Yrs.	Period after Perturbation Yrs.
1854 IV	*Jupiter*	0.13	1.46	114	0.0022	+111	−109	105.8	1089 ±100	395	216000
1885 III	*Jupiter*	0.21	1.54	118	0.0019	+194	−192	12.2	274 ± 90	204	398
1886 V	*Saturn*	0.020	1.75	127	0.0009	+ 79	− 74	84.1	771 ± 25	263	∞
1861 I	*Saturn*	0.110	1.59	123	0.0010	+370	−362	55.7	415 ± 6	336	533
1874 IV	*Uranus*	0.030	1.46	119	0.0008	+580	−570	45.4	306 ± 14	274	346
1853 II	*Neptune*	1.22	1.71	132	0.0005	±27000		84.9	782 ±200	778	786

(2) They may have been moving originally in nearly parabolic orbits, and have had their aphelion distances gradually reduced by the cumulative effect of ordinary perturbations.

(3) They may have been retarded by some other force, and so had their periods shortened.

(4) They may have "originally" had periods of the same order of magnitude as at present.

Of these four possible explanations, the third probably applies in the case of Comets 1843 I and 1882 II (which pass through the solar corona at perihelion and never come anywhere near any of the planets,) and is certainly a contributing factor in the case of ENCKE's Comet. The first has much to recommend it, since there is no reason why the observed comets should mostly be recent captures. But, since Jupiter must be far more effective in capturing comets than all the other planets put together, one would expect that, even after very considerable perturbations, there would remain a considerable excess of comets whose orbits passed fairly near that of *Jupiter*, above the number to be expected on a basis of chance; and this is not the case. If, then, this explanation is true, we must assume that in most cases the effect of perturbations since the encounter has changed the orbit greatly, with respect, at least, to its plane, or the longitude of perihelion. But, in elongated elliptical orbits, the major axis is more sensitive to small changes in the velocity (which are of course the initial effects of the disturbing forces) than the other elements. Hence the comets' periods should also have been changed along with the other elements, and almost all traces of the influence of the original encounter wiped out.

An idea of the order of magnitude of the perturbations which might be anticipated when the comet does not encounter any of the planets closely may be obtained from the perturbations of HALLEY'S Comet, which have been calculated by COWELL and CROMMELIN (18) for the past 28 revolutions. This comet passes nearer *Jupiter's* orbit than the average (0.77 astronomical units, as against an average of 1.34) and its orbit plane lies nearer that of the planetary system than in most other cases; so its perturbations are probably larger than the average.

The changes in the perihelion and node, though irregular, are decidedly progressive, the average changes per revolution of the comet being $+0^{\circ}.15$ for the node (19) and nearly the same for the perihelion. (20) If these rates are typical, we may expect that, after a captured comet has completed a hundred revolutions, its perihelion and node will have shifted some degrees, and the original close approach of its orbit to that of the capturing planet will have been widened out into a minimum distance of something like one-tenth that of the planet from the *Sun:* while after a thousand revolutions little trace of the original relationship will remain. The existing distribution of the orbits of the periodic comets is so nearly a random one that it seems probable that most of them, if originally captured, have made many hundred revolutions since.

The times of perihelion passage of Halley's Comet, the intervals between them, and the deviations of the observed times from those computed with a uniform period of 77.10 years, are given in Table VIII. A plot of the successive intervals between perihelion

TABLE VIII

PERIHELION PASSAGES OF HALLEY'S COMET

Date	Interval	Residual	Date	Interval	Residual
1910.30	74.42	−5.92	837.15	76.71	+0.33
1835.88	76.68	−3.24	760.44	75.59	+0.72
1759.20	76.49	−2.82	684.85	77.62	+2.23
1682.71	74.89	−2.20	607.23	76.36	+1.71
1607.82	76.17	0.00	530.87	79.37	+2.45
1531.65	75.21	+0.93	451.50	77.65	+0.18
1456.44	77.58	+2.82	373.85	78.58	−0.37
1378.86	77.05	+2.34	295.27	77.00	−1.85
1301.81	79.12	+2.47	218.27	77.04	−1.75
1222.69	77.39	+0.37	141.23	75.16	−1.69
1145.30	79.07	+0.08	66.07	77.30	+0.25
1066.73	76.52	−1.89	− 11.23	75.15	+0.05
989.71	77.16	−1.31	− 86.38	76.24	+2.00
912.55	75.40	−1.37	−162.62	77.01	+2.86
837.15		+0.33	−219.63		+2.95

passages shows two conspicuous features, — a regular alternation of longer and shorter intervals, differing by about $1\frac{1}{2}$ years, and a slower change, apparently also periodic, completing a cycle in ten periods of the comet, and with a double amplitude of nearly $2\frac{1}{2}$ years. The first of these is obviously explicable by the fact that two revolutions of the comet are, on the average, almost exactly equal to thirteen of *Jupiter*. It alternately accelerates and retards the perihelion passage by about four months. As for the slower fluctuations, a smooth sinusoidal curve of about 770 years period represents the residuals for the time of perihelion passage (after correction for the effect just described) with surprising accuracy for the 26 returns from B. C. 240 to A. D. 1759; but in two more revolutions the deviation from this curve has run up to fully five years. The fluctuation is therefore not simply periodic, and is probably of a very complicated

nature. The fact remains, however, that the perturbations of the period appear to be fluctuating, and not progressive, suggesting that it is probable that the mean period is constant, as in the case of a planet. The alterations in the period are, however, relatively great, — the average difference between the length of one revolution and the next being 1.55 years. If we compare each revolution with the next but one preceding (thereby eliminating a considerable part of the perturbations by *Jupiter*) the average difference is still 1.06 years. These changes in the period correspond respectively to alterations of the reciprocal of the mean distance $\frac{1}{a}$ by 0.00074 and 0.00050.

Taking the latter figure as a rough measure of the average perturbations of $\frac{1}{a}$ which may be expected at one perihelion passage of a comet, we find that, for a period of 500 years, the average difference between the length of one revolution and the next will be 24 years; for a period of 2000 years, 240 years while for a period of 10,000 years it amounts to 3,500 years.

For these longer periods, the configuration of the planets at the comet's next perihelion passage will depend almost entirely upon the magnitude of the perturbations which it experienced at the last one. It seems probable that in such a case the accumulation of perturbations at successive returns may radically alter the original period, and it is doubtful whether the comet can be said to have a "mean period" at all.

This leads back to the second alternative suggested above and suggests an inquiry into the distribution of periods which might be expected if the periodic comets owed their present orbits to the gradual accumulation of small perturbations.

The perturbations of a comet of long period take place, essentially, when it is fairly near the *Sun* and planets. Their amount will depend on the position of this part of the comet's orbit, and on the planetary configuration at the time of perihelion passage, but very little on the aphelion distance (provided this is great). At a given return, equal positive and negative perturbations of $\frac{1}{a}$ are probably nearly equally likely. Suppose that this is exactly true, and that the perturbations at successive returns take place at random. It follows that, for a given comet, $\frac{1}{a}$ will gradually diverge more and more from its initial value. Consider a large number of comets which come to perihelion within a given interval of time. The condition of a steady state as regards the distribution of $\frac{1}{a}$ is clearly that all values of this quantity shall be equally probable, — any given group, between definite limits of $\frac{1}{a}$, gaining as many members from the groups above and below it in the series as it loses to them. This law of distribution would, however hold good only over a limited interval, — failing for large values of $\frac{1}{a}$, — since the corresponding comets would be of short periods, and for these the perturbations at successive returns would not take place at random, — and also for very small values, since comets which are shifted out of this group by perturbations which make $\frac{1}{a}$ negative will never return, and stand no chance of being shifted back into it. For periods ranging from a few centuries to several thousand years, however, we should expect, on this hypothesis to find nearly equal members of comets in intervals defined by equal increments of $\frac{1}{a}$.

The actual distribution of periods is very different. In addition to the comets listed in Table III, for which the numbers are nearly equal for equal increments in $\sqrt{a}$, there are many more with still longer computed periods, and to these should be added the "hyperbolic" comets, (which, as STRÖMGREN (21) has shown, have all approached the solar system in elliptic orbits of very long period), and most of the less accurately observed "parabolic" comets.

This discordance indicates that there is something wrong about the assumptions on which the discussion is based. It may be that, even for comets of very long period, the perturbations of the mean distance are fluctuating and not progressive in the long run; or that there are certain positions of a comet's orbit in which the motion is stable, (22) and that the comets which satisfy these conditions have remained in our system, while others have been lost. However this may be, the second explanation may be tentatively rejected, pending some one's detailed examination of this interesting but difficult subject.

With respect finally to the fourth suggestion — that the periodic comets have "always" had about the same periods as at present, there is the obvious difficulty that comets lose some of their material every time they form a tail, and it seems improbable that they should last for the many thousands, — perhaps millions, — of perhelion passages demanded on this assumption.

The most probable conclusion appears therefore to be that the periodic comets owe their periodicity to captures by the major planets, but at no recent date, so that their orbits have since been much altered by subsequent perturbations. The periods have probably

suffered relatively unimportant changes during this time.

It does not follow, however, that the conventional attribution of the capture to that planet whose aphelion distance happens to be near that of the comet is well founded. *Jupiter* ought to be responsible for the vast majority and *Saturn* for practically all the rest. It may indeed be that some one comet, (such as 1866 I, associated with the Leonid meteors) may have been captured by *Uranus*, — though the chances are more than fifty to one against it in so small a sample; — but the conventional assignment of comets to the families of *Saturn*, *Uranus* and *Neptune* on a basis of their aphelion distances alone appears to be without justification.

The capture of a comet appears to be a rather rare event (as it should be theoretically). The production of a short-period comet should be still rarer. In view of the large number of the short-period comets, and the apparently short lives of some of them as visible objects, the theory that their number has been largely increased by disruption due to the tidal action of *Jupiter* is strongly confirmed by the present discussion.

Summary

The circumstances of closest possible approach to the major planets have been computed for all comets which are known to have periods less than 2,000 years.

The 42 comets of period exceeding ten years show an entirely different behavior from those of shorter period: their inclinations are high; the number with periods between two given limits is nearly proportional to the difference of the cube roots of the limiting periods; and few of them pass near the orbits of the planets.

The distribution of the distances of closest approach to the planetary orbits which might be expected if the comets' orbits were distributed at random has been approximately computed, and the observed distribution is in close agreement with it. An apparent deficiency of large distances of approach, especially north of the ecliptic, can be explained by the northern position of most terrestrial observers.

Only two of these comets approach any of the planets so closely that they may have been diverted directly into their present orbits by capture — 1854 IV, (period 1089 years) by *Jupiter*, and 1886 V (263 years) by *Saturn*.

The observed characteristics of the orbits of these comets can be satisfactorily represented on the assumption that they have been captured in the past, but so long ago that their orbits have since been greatly shifted in space by perturbations. The distribution of their periods accords closely with that predicted for captured comets by H. A. Newton's theory, and it is probable that their periods have undergone relatively much less change since capture. The theory that the periods have always been short appears less satisfactory, as also does that which attributes the present periods to the gradual accumulation of small perturbations. The latter leads to an expectation of many more short periods and fewer long ones than are actually found.

It is impossible to say with certainty what planet has been instrumental in capturing a given comet, except in a few cases of probably recent capture. On theoretical principles, it is probable that *Jupiter* has captured the great majority and *Saturn* the rest. There is some evidence of possible capture by *Uranus*, and none at all of capture by *Neptune*. The conventional description of the comets with aphelion distances about equal to those of *Saturn*, *Uranus* and *Neptune* as belonging to the "families" of these planets appears to be without secure foundation.

The well-known relation of the comets of period less than ten years to *Jupiter* is fully confirmed, and the belief that their large number is due to disruption by the action of the planet is strengthened.

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Princeton University Observatory,

1920, April 2[illegible]

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ASAPH HALL.

(Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.)

Date		G. M. T.	p	G. M. T.		Comp.	See'g	Remarks
		h m s	°	h m s	″			
1919 Nov.	5	21 8 34	275.34	21 10 54	13.80	4, 4	4	Moonlight at first.
	5	21 54 37	273.53	21 52 36	13.23	4, 4	3	
	16	20 51 58	307.85	20 53 19	16.65	4, 4	2 3	Foggy. Delayed by eyepieces fogging.
	22	20 37 34	304.19	20 41 16	16.84	4, 4	3 4	Clouds.
	24	19 54 25	166.54	19 56 3	12.97	4, 4	2 3	Fog and haze.
	24	20 53 26	163.57	20 54 34	13.22	4, 4	2 3	
Dec.	1	19 18 26	118.52	19 20 7	16.52	4, 4	2	Stopped by haze.
	3	20 17 6	334.92	20 21 24	13.76	4, 4	2–3	Delayed by moonlight.
	4	20 26 25	294.56	20 31 7	16.52	4, 4	2	Moonlight. Haze.
1920 Jan.	13	16 1 3	307.82	16 4 30	16.91	4, 4	3 4	
	13	16 51 6	303.83	16 52 2	16.84	4, 4	3–4	
	29	15 42 32	113.82	15 42 40	16.60	4, 4	3	Faint. Moonlight. Haze.
	29	16 23 14	113.23	16 27 32	16.21	4, 4	3	
Feb.	13	17 3 42	278.59	17 3 10	14.49	4, 4	2–3	Faint.
	13	17 36 22	279.04	17 57 20	13.96	2, 4	2–3	Object glass fogged.
	19	14 44 20	277.31	14 50 54	14.94	4, 4	3	Faint.
	19	15 37 52	275.75	15 37 22	14.50	4, 4	3	
	25	15 16 29	268.93	15 16 49	13.84	4, 4	3–4	Faint.
	25	16 10 59	267.22	16 7 57	13.32	4, 4	3–4	
Mar.	21	15 5 16	153.27	14 51 31	13.76	4, 4	2–3	Very faint. Wires flashing. Poor obs.
	22	14 49 5	114.01	14 32 28	15.85	4, 4	3	Faint. Delayed by aurora.
	22	15 53 40	111.80	15 50 6	16.00	4, 4	3	
	23	15 25 36	45.39	15 27 52	10.29	4, 4	2–3	Faint. Wires flashing. Stopped by haze.
	24	16 33 3	326.31	16 34 28	15.23	4, 4	3	Too poor to finish.
Apr.	10	14 37 28	15.36	14 37 23	10.50	4, 4	2–3	Used blue wires.
May	4	14 5 53	338.61	14 5 11	13.62	4, 4	2–3	Too faint to finish. Haze.

Seeing: 2 = good, 3 = fair, 4 = poor. Powers 367 and 388 were used.
Value of micrometer screw = 20″.8347 + 0″.000022 (t° − 50° F.) + 0″.0535 (0^{m}.810 − focal scale)

U. S. Naval Observatory, Washington, D. C.,
1920, August 6.

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OBSERVATIONS OF VARIABLE STARS,

By WILLIAM DOBERCK.

(Continued from A. J. 768.)

RR Persei: GRAFF's comparison stars were used and also A (*A. G. C. Cambr. U. S.* 1159) and B (1161). Their magnitudes were estimated as follows: A8.50, B8.78, o9.11, a9.74, b9.94. The step was taken equal to 0.1 mag. The maximum (8.6) occurred at 2421544. The value of the period is 389.7 days.

0595 v 3½ b	9.6	1190 v 1½ a	9.6	1824 l 1 v	.	2302 A 3 v 4 o	8.8
0760 v 3 o	8.8	1192 v 2 b	9.7	1826 l 3 v	.	2340 A 2 v 1 B	8.7
0774 v 2½ o	8.9	1499 o 4 v 5 a	9.4	1839 p 2 v	..	2343 v 1 A	8.4
0784 v 3 o	8.8	1511 v 3 o	8.8	2230 k 3 v		2355 B 2 v 2 o	9.0
0801 o 3 v 4 a	9.4	1517 A 3 v 3 B	8.6	2249 v = h	..	2363 o ½ v	9.2
1132 A 2½ v 2 B	8.7	1520 v = ½(A + o)	8.8	2251 v = h		2369 v 1 o	9.0
1138 A 2 v	8.7	1540 B 2 v	9.0	2282 o 5 v 3 b	9.6	2378 o 1½ v 5 a	9.3
1157 B 5 v 3 o	9.0	1568 o 1½ v	9.3	2287 o 2 v 5 a	9.3	2382 o 3 v	9.4
1165 v 1 o	9.0	1577 o 6 v 3 k	..	2300 A 5 v 3 o	8.9	2387 o 2 v	9.3

T Arietis: The H. C. comparison stars were used and their magnitudes determined as usual: a7.98, b8.44, c8.61, d8.87, e9.09, f9.48, g9.70, and h(10.02). The value of the step is 0.073 at 9.0 mag. The following maxima (all somewhat uncertain) are indicated: 0760 (9.2), 1689 (8.3), 1999 (8.3), and 2312 (8.5), and the following approximate minima 0892 (9.4), 1206 (9.3), and 1501 (9.5). The average maximum (8.4) occurred at 2421690, and the average minimum (9.4) at 1820, — 130 days after maximum, so that this is one of the stars, where the minimum occurs less than half a period after maximum. The period is irregular. Its average value appears to be 310 days. The extent of the variation seems in the past to have been double its present amount at times, and at other times to have been even less than what it is at present.

0432 c 2 v 3 e	8.80	0952 v = c	8.61	1607 v = d	8.87	1997 a 4 v 3 b	8.24
0451 c 2 v 3 e	.80	1153 e 3 v 2 f	9.32	1625 d 1 v 2 e	.94	1998 a 2 v 1 b	.29
0482 e 4 v 4 f	9.28	1165 e 2 v 3½ f	.23	1633 c ½ v	.64	1999 a 4 v 2 b	.29
0507 e 3 v 2 f	.32	1183 e 5 v 3 f	.33	1641 c 2 v 1 d	.78	2001 a 3 v 2 b	.25
0534 v = ½(e + f)	.29	1194 e 4 v 1½ f	.38	1661 b 1 v 2 c	.50	2020 b 2 v 1 c	.55
0578 e 2 v 3 f	.25	1206 e 3 v 2 f	.32	1662 b 1 v 2 c	.50	2024 b 2 v	.59
0760 e 1 v 3 f	.19	1258 e 3½ v 1 f	.39	1675 v 1 b	.37	2249 e 2 v 3 f	9.25
0775 e 1 v 5 f	.15	1501 e 3 v 2 g	.46	1683 v 3 b	.22	2250 e 3 v 2 f	9.32
0784 e 2 v 4 f	.22	1525 e 2 v 3 f	.25	1689 a 7 v 3½ b	.29	2282 v = c	8.61
0807 e 2 v 4 f	.22	1537 e 2½ v 3 f	.22	1875 f 2 v 3 g	9.55	2287 b 1 v 1 c	.52
0892 e 3 v 2 f	.32	1540 e 2 v 3½ f	.23	1901 d 1 v 1 e	8.98	2288 v = c	.61
0892 f 3 v 2 g	.61	1549 d 2 v 2 e	8.98	1906 c 1 v	.68	2295 b 2 v 1 c	.55
0899 e 1 v 3 f	.19	1558 v 1 d	.80	1920 v = c	.61	2312 b 2 v 1 c	.55
0911 e 3 v 3 f	.29	1566 v = e	9.09	1935 v = c	.61	2340 v 1 b	.37
0924 c 3½ v 1 d	8.81	1577 c 1½ v 2 e	8.82	1951 c 1 v	.68	2343 v = c	.61
0941 c 2 v 3 d	.71	1601 b 1 v 2 c	8.50	1976 v = c	.61		

W Tauri: The H. C. magnitudes of the comparison stars were used. The value of the step is about 0.13. This is an irregularly variable star. Maxima occurred at 0931 (8.4) and at 2010 (8.9), and minima at 0526 (12.5), 1190 (10.2), 1625 (11.6), 1928 (10.6), and at 2287 (10.1).

0483 *g* 4 *v* 5 *k*	10.9	1258 *v* = *g*	10.4	1675 *v* 3 *f*	9.8	2024 *v* 1½ *c*	8.9
0509 *l* 3 *v*	12.4	1274 *h* 5 *v* 2 *k*	11.2	1683 *v* 4 *f*	9.6	2048 *c* 3 *v*	9.5
0544 *m* 5 *v*	12.7	1293 *c* 5 *v* 3 *f*	9.8	1686 *v* 4 *f*	9.6	2057 *c* 3 *v*	9.5
0578 *g* 3 *v* 5 *k*	10.8	1306 *f* 1 *v* 5 *h*	10.3	1928 *g* 2 *v*	10.7	2250 *d* 5 *v* 3 *f*	9.5
0892 *d* 5 *v* 10 *g*	9.1	1311 *m* 3 *v*	12.5	1951 *v* 3 *g*	10.0	2251 *d* 4 *v* 5 *f*	9.2
0900 *d* 3 *v* 5 *f*	9.1	1555 *f* 2 *v*	10.4	1959 *v* = *g*	10.4	2282 *c* 1 *v*	9.3
0931 *d* 4 *v* 3 *c*	8.8	1565 *v* 2 *h*	10.6	1976 *v* 2 *f*	9.9	2287 *v* 3 *g*	10.0
0949 *d* 4 *v* 6 *f*	9.1	1581 *h* 2 *v*	11.1	1981 *d* 4 *v* 4 *f*	9.3	2289 *v* 3 *f*	9.8
1156 *c* 5 *v* 3 *f*	9.8	1625 *k* 2 *v*	11.7	1985 *d* 5 *v* 5 *f*	9.3	2295 *c* 3 *v* 5 *f*	9.5
1190 *v* 2 *g*	10.2	1633 *h* 3 *v* 1 *k*	11.3	1997 *v* 2 *c*	8.9	2312 *c* 7 *v* 4 *g*	10.0
1192 *c* 10 *v* 3 *g*	10.1	1642 *h* 1 *v*	11.0	1998 *v* 2 *c*	8.9	2340 *g* 2 *v* 1 *h*	10.7
1206 *c* 3½ *v*	9.6	1654 *f* 3 *v* 1 *g*	10.3	2001 *v* 1½ *c*	8.9	2343 *g* 1 *v*	10.6
1223 *c* 3 *v* 5 *f*	9.5	1673 *v* 3 *f*	9.8	2020 *d* 6 *v* 1½ *c*	9.0		

R Orionis: The magnitudes of the H. C. comparison stars were used and also *g'*(*A. S. V.* 7) 10.8, compared here. The step was supposed equal to 0.1 mag. By laying a parabola through three points of the light curve the epoch of maximum (9.15) was found to be 2420583 and the period 377.14 days.

0486 *h* 2 *v*	11.44	0578 *v* = *b*	9.18	0901 *h* 4 *v* 5 *k*	11.64	1258 *h* 3 *v* 5 *k*	11.57
0509 *g'* 2 *v* 3 *h*	10.97	0892 *h* 3 *v*	11.54	0941 *b* 2 *v* 4 *c*	9.35	1311 *c* 2 *v* 3 *d*	9.79
0538 *g'* 2 *v*	10.99	0900 *g'* 2 *v* 2 *h*	11.02	0949 *b* 3 *v* 3 *c*	9.42	2282 *h* 2 *v* 4 *k*	11.53

W Aurigæ: The magnitudes of the H. C. comparison stars were used. The value of the step was 0.07 mag. Maximum (9.26) occurred at 2421544. The period is 275.8 days.

0464 *a* 3 *v* 2 *b*	9.16	1532 *v* 3 *d*	9.34	2083 *v* 4 *c*	9.23	2369 *d* 2 *v* 2 *c*	9.71
0509 *n* 2 *v*	11.65	1546 *a* 2 *v* 3 *c*	9.20	2250 *k* 5 *v* 2 *n*	11.31	2377 *c* 2 *v* 1½ *f*	9.99
0952 *l* 5 *v* 3 *m*	11.38	1566 *c* 1 *v* 1 *d*	9.53	2251 *v* 3 *n*	11.30	2381 *c* 2 *v* 3 *d*	9.53
1258 *d* 1 *v* 3 *c*	9.63	1575 *g* 3 *v*	10.67	2340 *v* 1 *c*	9.44	2382 *v* = *c*	9.87
1274 *b* = *v* 2 *d*	9.34	1577 *f* 4 *v* 5 *g*	10.25	2343 *v* = *c*	9.51	2387 *c* 3 *v* 2 *f*	10.00
1293 *d* 3 *v* 1 *c*	9.79	1581 *k* 2 *v*	10.98	2344 *c* 1 *v* 2 *d*	9.52	2392 *f* 1 *v*	10.15
1306 *v* = *f*	10.08	1596 *v* 2 *l*	11.11	2345 *c* 1 *v* 2 *d*	9.52	2415 *k* 1 *v*	10.91
1311 *c* 2 *v* 3 *f*	9.95	1601 *n* 2 *v*	11.65	2355 *c* 2 *v* 1 *d*	9.54		
1328 *g* 3 *v* 2 *k*	10.69	1633 *q* 4 *v*	12.50	2363 *v* = *c*	9.87		

RR Tauri: The magnitudes of the H. C. comparison stars were used. The value of the step was 0.1 mag. This is an irregularly variable star.

0509 *f* 1 *v*	10.64	0595 *v* = *l*	12.10	1258 *o* 5 *v*	....	1633 *h* 1½ *v* 3 *k*	11.38
0515 *c* 3 *v* 3 *h*	10.92	0903 *l* 3 *v*	12.40	1540 *k* 7 *v* 5 *l*	11.85	1661 *k* 3 *v* 2 *l*	11.87
0514 *c* 3 *v*	10.83	0941 *k* 3 *v* 3 *l*	11.80	1565 *g* 5 *v* 3 *h*	11.10	1686 *v* 1 *m*	12.50
0588 *h* 2 *v*	11.51	1192 *v* = *f*	10.54	1621 *g* 2 *v* 1 *h*	11.11	2289 *k* 3 *v* 3 *l*	11.80

U Aurigæ: The magnitudes of the H. C. comparison stars were used. The value of the step was 0.080 mag. at 9.0, and 0.097 at 11.0. Maximum (8.5) occurred at 2421958. The period is 408.2 days.

0465 *n* 3 *v* 3 *p*	11.51	1258 *v* = ½(*r* + *t*)	12.49	1311 *n* 3 *v* 5 *p*	11.44	1540 *c* 1 *v* 2 *d*	8.75
0899 *v* 1 *q*	11.86	1286 *m* 4 *v* 1 *n*	11.19	1328 *v* = *n*	11.24	1565 *v* 1 *g*	9.50
1194 *v* = *m*	10.97	1306 *n* 2 *v* 5 *o*	11.36	1342 *m* 4 *v* 1 *n*	11.19	1581 *g* 1 *v*	9.66

1596 *h* 3 *v* 1 *k*	10.24	1970 *c* 1 *v* 3 *d*	8.74	2058 *m* 1 *v*	11.06	2355 *c* 2 *v* 1 *d*	8.78
1615 *m* 3 *v*	11.21	1975 *c* 1 *v*	8.80	2070 *n* 2 *v*	11.43	2363 *v* = *c*	8.72
1626 *m* 1½ *v* 2 *n*	11.09	1981 *d* 1 *v*	8.88	2251 *v* 2 *m*	10.77	2366 *v* = *d*	8.80
1633 *n* 2 *v* 4 *p*	11.42	1985 *v* 1 *e*	9.03	2282 *v* = *m*	10.97	2369 *v* = *c*	8.72
1641 *m* 1½ *v* 1½ *n*	11.11	1997 *d* 3 *v* 1 *e*	9.03	2287 *v* = ½ *m* + *n*	11.11	2377 *d* ½ *v*	8.84
1660 *n* 3 *v* = *p*	11.66	1998 *f* 2 *v* 1 *g*	9.49	2288 *v* = *m*	10.97	2381 *c* 1 *v* 3 *e*	8.87
1674 *m* 2 *v* 3 *n*	11.08	1999 *f* 3 *v* 1 *g*	9.52	2295 *n* 2 *v*	11.43	2388 *b* 2 *v* 1 *c*	8.52
1683 *n* 1 *v*	11.33	2001 *f* 2 *v* 3 *g*	9.12	2340 *e* 3 *v* 2 *f*	9.24	2392 *c* 1 *v* 2½ *d*	8.74
1957 *b* 2 *v*	8.27	2020 *g* 2 *v* 1 *h*	9.71	2343 *c* 1 *v* 2 *d*	8.75	2415 *f* 2 *v* 1 *g*	9.49
1959 *b* 2 *v* 1½ *c*	8.46	2024 *g* 1½ *v* 3 *h*	9.65	2344 *c* 1 *v* 2 *d*	8.75		
1967 *b* 3 *v* 2 *c*	8.48	2057 *m* 3 *v* 2 *n*	11.13	2345 *d* 1 *v* 2 *e*	8.90		

V Aurigæ: The magnitudes of the H. C. comparison stars were used and also *d*′(*A. S. V.* 9) 9.66, and *h*′ 20) 10.94, which were compared here. The value of the step is 0.075 mag. Maximum (8.9) occurred at 2421551. The period is 352.6 days. Minimum (11.9) occurred at 1704 (153 days, less than half a period, after maximum). The curve varies in different periods. The minimum magnitude varied between 11.2 and 12.7.

0509 *v* = *d*	9.4	1286 *v* = *k*	11.1	1633 *d*′ 3 *v*	9.9	1997 *h* 1 *v*	11.0
0577 *d* 3 *v* 3 *e*	9.7	1306 *f* 2 *v* 3 *g*	10.5	1641 *d*′ 2 *v* 3 *f*	9.9	1998 *v* = *g*	10.6
0595 *d* 3 *v* 3 *e*	9.7	1316 *v* = *h*′	10.9	1660 *v* = *h*	10.9	1999 *f* 2 *v* 3 *g*	10.5
0605 *d*′ 3 *v* 3½ *f*	10.0	1328 *k* 5 *v* 2 *l*	11.3	1662 *g* 2 *v* 2 *h*	10.8	2019 *h* 2 *v* 3 *k*	11.0
0617 *d* 3 *v* 2 *e*	9.7	1332 *v* = *s*	12.7	1671 *f* 3 *v* 2 *h*′	10.7	2024 *v* = *l*	11.4
0901 *v* 2 *d*	9.2	1339 *m* 3 *v* 5 *s*	12.0	1673 *e* 4 *v* 1 *f*	10.3	2058 *h*′ 2 *v* 2 *m*	11.3
0941 *d* 4 *v* 2 *d*′	9.6	1342 *q* 1 *v* 1 *s*	12.6	1677 *f* 3 *v* 3 *h*′	10.6	2070 *v* = *s*	12.7
0947 *v* 2 *f*	10.2	1355 *f* 2 *v* 3 *g*	10.5	1683 *f* 3 *v* 5 *g*	10.4	2250 *c* 3 *v* 3 *d*′	9.1
0952 *e* 1 *v* 2 *f*	10.1	1357 *f* 4 *v* 3 *g*	10.5	1690 *f* 3 *v* 3 *g*	10.5	2282 *b* 2 *v* 2 *c*	8.8
0965 *f* 5 *v* 3 *g*	10.5	1532 *b* 4 *v* 5 *c*	8.8	1711 *v* = *k*	11.1	2288 *d* 1 *v* 3 *e*	9.5
0977 *g* 3 *v*	10.8	1540 *b* 4½ *v* 3 *c*	8.9	1716 *g* 3 *v* 3 *h*′	10.8	2289 *d* 3 *v* 2 *e*	9.7
0983 *h* 3 *v* 3 *k*	11.0	1565 *c* 3 *v* 5 *d*	9.2	1723 *f* 1½ *v*	10.5	2294 *d* 2 *v* 4 *e*	9.6
0984 *g* 2 *v* 3 *h*	10.7	1575 *d* 3 *v* 3 *e*	9.7	1727 *f* 1 *v* 3 *g*	10.4	2312 *v* = *d*′	9.7
0992 *m* 2 *v* = *n*	11.8	1577 *c* 1 *v* 2*d*′	9.3	1951 *v* 2 *d*	9.3	2340 *d* 2 *v* 2 *e*	9.7
0999 *g* 3 *v* 2 *h*′	10.8	1607 *d* 3 *v* 2 *e*	9.7	1957 *v* 2 *d*	9.3	2343 *e* 1 *v* 2 *f*	10.1
1192 *v* 2½ *d*	9.2	1626 *d*′ 1½ *v* 4 *e*	9.7	1985 *d*′ 3 *v* 2 *g*	10.2	2345 *d*′ 1 *v* 2 *e*	9.8

R Geminorum: The magnitudes of the H. C. comparison stars were adopted and also *s*′(*A. S. V.* 31) 11.51 and *s*″(*A. S. V.* 39) 11.98. The value of the step was 0.1 mag. Maximum occurred at 2421934. The maximum magnitude varies between 6.3 and 7.9. The period is variable.

0538 *v* = *s*′	11.5	1328 *v* 2 *t*	11.9	1689 *v* = *t*	12.1	2058 *v* 2 *s*′	11.3
0562 *s*′ 2 *v*	11.7	1342 *s* 5 *v*	12.1	1957 *v* 1 *h*	7.8	2070 *s*′ 2 *v* 1 *t*	11.9
0577 *v* = *s*′	11.5	1577 *h* 1 *v* 2 *k*	8.0	1960 *h* 3 *v*	8.2	2288 *c* 3 *v* 2 *d*	6.3
0595 *s*″ 3 *v*	12.3	1596 *k* 2 *v* 2 *l*	8.4	1967 *h* 3 *v* 1 *k*	8.2	2292 *c* 5 *v* 3 *e*	6.5
0900 *o* 3 *v* 5 *q*	10.1	1621 *n* 2 *v* 5 *o*	9.4	1975 *h* 2 *v* 1 *k*	8.1	2294 *d* 1 *v*	6.6
0924 *v* = *s*	11.6	1640 *o* 5 *v* 5 *q*	10.2	1997 *m* 1 *v* 2½ *n*	9.0	2312 *e* 5 *v* 10 *h*	7.2
0949 *s*′ 4 *v*	11.9	1654 *v* 3 *q*	10.5	1998 *l* 1 *v* 2 *m*	8.7	2340 *k* 2 *v* 1 *l*	8.5
1192 *v* 2½ *h*	7.7	1662 *q* 3 *v*	11.1	1999 *l* 2½ *v* 1½ *m*	8.8	2343 *k* 1 *v* 2½ *l*	8.4
1258 *v* 1 *m*	8.8	1674 *v* 2 *s*′	11.3	2020 *v* 1½ *q*	10.6	2345 *k* 2 *v* = *l*	8.6
1286 *o* 5 *v* 5 *q*	10.2	1675 *v* 4 *s*′	11.1	2024 *n* 2 *v* 3 *o*	9.4		
1306 *v* 3 *q*	10.5	1683 *s* 2 *v* 3 *t*	11.8	2057 *v* 2 *s*′	11.3		

R Canis Minoris: The magnitudes of the H. C. comparison stars were used except *c*8.22, *f*8.57, *g*8.97, *h*9.24, and *k*9.49, which were compared here. The value of the step was 0.067 mag. at 9.0. Maximum (7.9) occurred at 2421702. The period is 337.7 days. The curve varies considerably.

0538 *m* 3 *v* 2 *n*	9.95	0983 *c* 3 *v* 3 *f*	8.39	1643 *f* 2 *v* 4 *g*	8.70	1997 *f* ½ *v*	8.60
0562 *v* 2 *k*	9.35	0984 *e* 4 *v* 1 *f*	8.50	1654 *e* 3 *v* 1 *f*	8.48	1998 *f* 4 *v* 2 *g*	8.84
0569 *k* 2 *v*	9.62	0991 *c* 4 *v* 3 *f*	8.42	1661 *v* 1½ *f*	8.47	1999 *v* = *f*	8.57
0576 *h* 3 *v* 2 *k*	9.39	0999 *c* 3 *v* 3 *e*	8.06	1671 *e* 3 *v* 3 *f*	8.40	2001 *v* ½ *f*	8.54
0588 *v* 2 *k*	9.35	1258 *m* 2 *v* 2 *n*	9.92	1683 *e* 3 *v* 2 *f*	8.43	2020 *v* 1 *f*	8.50
0602 *v* 1 *e*	8.15	1286 *g* 1 *v* 1 *h*	9.10	1710 *b* 3 *v* 1 *c*	7.72	2024 *e* 3 *v* 2 *f*	8.43
0611 *f* 3 *v*	8.77	1307 *f* 2½ *v* 5 *h*	8.79	1711 *c* 2 *v* 4 *e*	8.00	2057 *v* 1½ *e*	8.12
0625 *e* 3 *v* 2 *f*	8.43	1317 *f* 1 *v*	8.64	1716 *v* 3 *c*	7.69	2058 *c* 3 *v* 3 *e*	8.05
0900 *k* 1 *v* 3 *l*	9.56	1328 *v* = *f*	8.57	1722 *b* 3 *v* 3 *c*	7.55	2070 *c* 3 *v* 3 *d*	8.05
0931 *g* 3 *v* 1 *h*	9.17	1342 *v* = *f*	8.57	1723 *v* 1 *c*	7.82	2288 *v* = *l*	9.77
0941 *g* 3 *v* 3 *h*	9.10	1357 *e* 2½ *v* 3½ *f*	8.37	1960 *v* = *k*	9.49	2292 *k* 1 *v*	9.56
0959 *f* 3 *v* 2 *g*	8.81	1625 *v* 1½ *h*	9.14	1967 *v* 2½ *h*	9.08	2312 *h* 1 *v* 3 *k*	9.30
0965 *f* 1 *v*	8.64	1640 *f* 5 *v* 2 *g*	8.86	1970 *h* 2 *v* 3 *k*	9.34	2340 *f* 2 *v* 4 *h*	8.79
0979 *v* 2 *e*	8.08	1641 *f* 1 *v*	8.64	1981 *h* ½ *v*	9.27	2343 *f* 4 *v* 3 *h*	8.95
				1985 *f* 2 *v* 3½ *k*	8.90	2345 *f* 3 *v* 3 *g*	8.77

S Canis Minoris: The magnitudes of the H. C. comparison stars were used. The value of the step was 0.084 mag. at 10½. Minima were observed at 0984 (11.5), 1342 (12.3), 1689 (12.5), 2363 (12.5). The average minimum (12.2) occurred at 2421681. The period is irregular. At present it is about 345 days. Its average value appears to be about 331 days.

0538 *b* 1 *v*	7.14	0947 *l* 5 *v* 3 *n*	10.52	1317 *v* = *o*	11.26	1689 *q* 5 *v* 2 *r*	12.55
0562 *v* 3 *c*	7.81	0959 *n* 5 *v* 6 *o*	11.02	1328 *v* = *p*	11.70	1960 *m* 2 *v*	10.61
0576 *b* 6 *v* 1 *e*	7.92	0965 *l* 5 *v* 1 *m*	10.37	1342 *v* = *q*	12.26	1975 *n* 3 *v*	11.07
0588 *g* 3½ *v*	9.08	0969 *m* 4 *v*	10.78	1625 *v* = *m*	10.44	2288 *l* 2 *v* 3 *m*	10.19
0602 *g* 5 *v* 4 *l*	9.47	0977 *n* 4 *v* 3 *o*	11.08	1640 *n* 1 *v* 3 *o*	10.93	2292 *v* = *m*	10.44
0611 *v* = *l*	10.02	0984 *o* 5 *v* 3 *p*	11.53	1641 *m* 2 *v* 2 *n*	10.63	2312 *n* 2 *v* 3 *o*	11.00
0616 *v* 1½ *l*	9.89	0991 *o* 1 *v*	11.34	1654 *o* 2 *v*	11.43	2340 *o* 3 *v*	11.51
0625 *n* 3 *v*	11.07	1258 *f* 4 *v* 1 *g*	8.73	1661 *o* 3 *v* 1 *p*	11.59	2345 *p* 2 *v* 2 *q*	11.98
0900 *e* 1 *v* 1 *f*	8.27	1286 *k* 3 *v* = *l*	9.96	1671 *p* 1½ *v*	11.83	2363 *q* 3 *v*	12.51
0931 *h* 3 *v* 3 *k*	9.47	1307 *n* 2 *v* 3 *o*	11.00	1683 *q* 2 *v* 2 *r*	12.47	2366 *v* 1 *q*	12.18

U Canis Minoris: The magnitudes of the H. C. comparison stars were used and also *a*′(*A. S. V.* 3) 8.83, *b*′(2) 9.0, *b*″(18) 9.3, and *c*′(31) 9.6, which were roughly compared here. The value of the step was 0.10 mag. Maxima were observed at 2420916 (8.20), and at 2421329 (8.36). The period is 414 days.

0538 *a*′ 4 *v* 7 *b*	8.9	0969 *b*′ 2 *v* 5 *c*	9.2	1350 *v* 1½ *a*	8.4	1997 *b*″ 3 *v* = *c*′	9.6
0562 *v* 1½ *b*	8.8	0979 *a*′ 3 *v* 2 *c*	9.2	1625 *a*′ 3 *v* 2 *c*	9.2	2020 *c* 1 *v* 3 *d*	9.6
0576 *b* = *v* 3 *b*″	9.0	0999 *d* 3 *v*	10.2	1640 *a*′ 3 *v* 2 *c*	9.2	2024 *v* 1 *c*	9.4
0602 *v* 1 *b*″	9.2	1258 *a*′ 1 *v* 4 *c*	9.2	1661 *v* = *c*	9.5	2057 *a*′ 2 *v* 5 *c*	9.0
0617 *c*′ 3 *v*	9.9	1286 *a* 3 *v* 4 *a*′	8.7	1674 *c* 1½ *v* 3 *d*	9.6	2058 *a*′ 2 *v* 4 *c*	9.1
0900 *v* 3 *a*	8.2	1307 *v* 2½ *a*	8.2	1683 *v* = *c*	9.5	2070 *a*′ 2 *v*	9.0
0931 *v* 3 *a*	8.2	1317 *a* 1 *v*	8.6	1710 *a*′ 1 *v* 3 *c*	9.0	2083 *b*′ 2 *v*	9.2
0965 *a*′ 2 *v* 1 *c*	9.0	1342 *v* 2½ *a*	8.3	1716 *a* ′1½ *v*	9.0		

V Lacertæ: The H. C. comparison stars were used: *a*8.18, *b*8.66, *c*8.57, *d*8.99, *e*9.19, *f*9.55, *g*9.60, and *h*9.64. They were observed in steps and reduced to H. C. scale. The value of the step is 0.09 mag. Maximum (8.21) occurred at 2421650.20 and minimum (9.27) 3.74 days after maximum. The period is 4.98344 days (increasing). The shape of the curve appears to be variable. Both maxima and minima are sharply marked at present. The following are the twelve equidistant ordinates, beginning with maximum: 8.21, 8.32, 8.44, 8.61, 8.77, 8.88, 8.98, 9.08, 9.17, 9.27, 9.01, 8.62. They are represented by the formula:

$$\begin{aligned}\text{Mag.} = 8.78 &- 0.43\cos(x - 42^\circ) - 0.16\cos(2x - 15^\circ)\\ &+ 0.06\cos(3x - 31^\circ) - 0.02\cos 5x\\ &- 0.02\cos 6x\end{aligned}$$

0356.39	*d* 1 *v*	9.08	0801.24	*e* 1 *v* 3 *f*	9.28	1781.41	*v* = *c*	8.57	2117.45	*e* 1 *v*	9.28
0357.37	*e* 1 *v* 1 *d*	9.09	0804.38	*a* 6 *v* 2 *b*	8.54	1783.44	*e* 1 *v*	9.28	2118.45	*a* 1 *v*	8.27
0358.36	*d* 1 *v* 1 *e*	9.09	0807.31	*v* = *e*	9.19	1784.42	*c* 2 *v* 1 *b*	8.60	2119.47	*v* = *c*	8.57
0361.38	*c* 3 *v* 2 *d*	8.82	0807.39	*c* 3 *v* 2 *d*	8.82	1787.42	*b* 2 *v* 1½ *d*	8.85	2120.42	*c* 1 *v* 1 *b*	8.62
0362.37	*v* = *e*	9.19	0807.41	*c* 3 *v* 1 *d*	8.89	1793.47	*v* = *e*	9.19	2121.43	*d* 2 *v* 2 *c*	9.09
0366.36	*v* 1 *d*	8.90	0887.29	*c* 2 *v* 2 *d*	8.78	1796.45	*b* 2 *v* 3 *d*	8.79	2123.45	*a* 3 *v* 2 *c*	8.41
0368.34	*e* 1 *v* 2 *h*	9.35	0892.25	*b* 2 *v* 3 *d*	8.79	1812.39	*v* = *e*	9.19	2124.45	*a* 3 *v* 3 *b*	8.42
0384.40	*v* 2 *c*	8.39	0899.23	*b* 3 *v* 1½ *d*	8.88	1820.43	*a* 3 *v* 2 *c*	8.41	2125.11	*b* 1 *v* 3 *d*	8.71
0384.41	*a* 3 *v*	8.45	0901.25	*v* = *e*	9.19	1824.46	*a* 1 *v* 3 *c*	8.31	2126.43	*v* 1 *d*	8.90
0398.31	*e* 1 *v* = *f*	9.42	0903.26	*v* = *c*	8.57	1826.37	*b* 3 *v* 2 *e*	8.98	2127.44	*d* 1 *v* 2 *e*	9.06
0398.40	*e* 1 *v*	9.28	0924.27	*b* 2 *v* 2 *d*	8.82	1827.35	*v* = *e*	9.19	2128.43	*a* 2½ *v* 4 *c*	8.33
0453.38	*v* 1 *d*	8.90	1036.42	*b* 4 *v* 2½ *d*	8.86	1828.34	*e* 1 *v*	9.28	2136.46	*v* = *d*	8.99
0468.34	*d* 2 *v* 2 *e*	9.09	1036.53	*b* 1½ *v* 2 *d*	8.79	1830.36	*a* 2 *v* 2 *c*	8.38	2155.40	*b* 1 *v* 3 *d*	8.74
0515.36	*c* 3 *v* 3 *d*	8.78	1070.38	*d* 2 *v* 1 *e*	9.12	1838.37	*e* 2 *v* 3 *f*	9.33	2176.37	*d* 1½ *v* 2 *e*	9.08
0534.25	*a* 3 *v* 4 *c*	8.34	1075.45	*e* 1 *v*	9.28	1839.42	*v* 1½ *a*	8.04	2177.39	*v* = *e*	9.19
0548.27	*v* = *d*	8.99	1076.38	*b* 2 *v* 2 *d*	8.82	1813.10	*e* ½ *v*	9.23	2178.39	*v* 1 *a*	8.09
0667.44	*d* 1 *v* 1 *e*	9.09	1096.37	*e* 1 *v* 3 *f*	9.28	1844.39	*a* 1 *v* 4 *c*	8.26	2180.38	*b* ½ *v*	8.70
0670.42	*c* 1 *v* 1 *d*	8.78	1391.45	*v* = *a*	8.18	1845.34	*v* 1 *c*	8.48	2182.37	*b* 2 *v* 1 *d*	8.88
0696.46	*v* = *e*	9.19	1476.33	*a* 3 *v* 1 *c*	8.47	1847.35	*d* 1 *v* = *e*	9.14	2184.42	*v* = *c*	8.57
0709.45	*b* 1 *v* 1 *c*	8.61	1476.37	*a* 3 *v*	8.45	1852.35	*v* = *e*	9.19	2186.36	*b* 3 *v* 3 *d*	8.82
0711.39	*e* 2 *v* 3 *f*	9.33	1499.38	*e* 1 *v* 3 *f*	9.28	1860.40	*a* 3½ *v* 3 *c*	8.39	2187.35	*d* 1 *v* = *e*	9.14
0717.35	*v* 3 *e*	8.92	1503.32	*d* 1 *v* 2 *e*	9.06	1862.30	*v* = *e*	9.19	2192.37	*d* 1 *v*	9.08
0717.38	*d* 3 *v* 1 *e*	9.14	1508.31	*d* 1 *v* 3 *e*	9.04	1864.39	*v* 3 *a*	7.91	2193.35	*a* 3 *v* 1 *c*	8.47
0721.34	*v* 1 *d*	8.90	1521.35	*a* 5 *v* 3 *c*	8.43	1865.31	*c* 1 *v* 3 *d*	8.67	2198.41	*v* 1 *a*	8.09
0722.45	*d* 2 *v* 2 *e*	9.09	1540.38	*a* 3 *v* 2 *c*	8.41	1870.34	*a* 3 *v* 2 *c*	8.41	2210.41	*b* 3 *v* 2 *d*	8.86
0742.45	*d* 1 *v* 1½ *e*	9.07	1565.38	*a* 2 *v* 3 *c*	8.34	1873.29	*v* = *e*	9.19	2211.33	*b* 2 *v* 2 *d*	8.82
0742.46	*c* 5 *v* 1 *d*	8.92	1643.28	*d* 3 *v* 1 *e*	9.14	1875.29	*a* 1½ *v* 2 *c*	8.34	2212.32	*e* 1 *v*	9.28
0747.43	*v* 2 *d*	8.81	1727.50	*v* 1 *e*	9.10	1880.29	*a* 2 *v* 3 *c*	8.34	2212.47	*d* 2 *v* ½ *e*	9.15
0748.39	*a* 1 *v* 3 *c*	8.28	1730.46	*v* 1 *a*	8.09	1901.48	*c* 3 *v* 2 *d*	8.82	2213.32	*a* 2 *v* 3 *c*	8.34
0749.39	*v* = *b*	8.66	1732.48	*v* 1 *d*	8.90	1907.22	*c* 1 *v* 2 *e*	8.78	2214.34	*a* 3 *v* 1 *c*	8.47
0750.40	*v* = *b*	8.66	1734.44	*a* 2½ *v*	8.40	1931.34	*d* 1 *v* 1 *e*	9.09	2218.38	*v* 1 *a*	8.09
0751.42	*d* 2 *v* 1 *e*	9.12	1741.45	*c* 2 *v* 3 *d*	8.74	1970.35	*b* 2 *v*	8.84	2219.33	*a* 2 *v* 2 *c*	8.38
0752.30	*e* 1 *v* 3 *f*	9.28	1743.47	*d* 1 *v* 2 *e*	9.06	1976.29	*v* 1 *d*	8.90	2223.11	*v* 4 *a*	7.82
0752.37	*d* = *v* 1 *e*	9.04	1744.45	*v* = *b*	8.66	2024.29	*a* 1½ *v* 2½ *c*	8.33	2230.29	*v* = *b*	8.66
0752.45	*c* 1 *v* 1 *b*	8.61	1745.46	*a* 2 *v* 3 *c*	8.34	2093.46	*c* = *v* 1 *b*	8.57	2231.36	*d* ½ *v*	9.04
0753.37	*a* 2 *v* 2 *c*	8.37	1746.42	*b* 3 *v* 2 *d*	8.86	2096.48	*d* 4 *v* 1 *e*	9.14	2232.27	*d* 2 *v* 2 *e*	9.09
0758.53	*c* 2 *v* 3 *d*	8.74	1760.43	*a* 1 *v*	8.27	2098.48	*a* 2 *v* 3 *c*	8.34	2232.37	*d* 1½ *v* 2½ *e*	9.06
0760.34	*c* 3 *v* 3 *d*	8.78	1761.46	*c* 1 *v* 1 *b*	8.62	2099.49	*a* 1 *v*	8.27	2242.26	*e* 1 *v*	9.28
0761.33	*e* 2 *v* 3 *f*	9.33	1767.49	*v* 1 *e*	9.10	2100.47	*b* = *c* 1 *v*	8.67	2242.39	*d* 2 *v* 4 *e*	9.06
0770.37	*c* 1 *v* 2½ *e*	8.75	1768.43	*e* ½ *v*	9.24	2101.46	*c* 1½ *v* 2 *d*	8.75	2245.26	*b* 1 *v* 3 *d*	8.74
0779.28	*c* 3 *v* 4 *d*	8.75	1770.49	*a* 2 *v* 1 *c*	8.44	2102.46	*v* 1 *e*	9.10	2247.28	*v* = *d*	8.99
0785.30	*c* 2 *v* 1 *d*	8.85	1777.47	*b* 2 *v* 1 *d*	8.88	2107.46	*v* = *e*	9.19	2249.26	*b* 2 *v* 2 *d*	8.82
0791.30	*b* 3 *v* 2 *d*	8.86	1778.49	*v* = *e*	9.19	2115.45	*b* 2 *v* 1 *d*	8.88	2250.26	*b* 1 *v*	8.75

2251.27	*v* = *c*	9.19	2258.25	*a* 1 *v* 3 *c*	8.28	2289.22	*v* 1 *c*	8.48	2295.37	*v* 1 *d*	8.90
2253.26	*v* 2½ *a*	7.96	2282.26	*v* = *c*	9.19	2292.39	*c* 1 *v* 2 *d*	8.71	2312.39	*v* = *d*	8.99
2254.26	*v* 1 *c*	8.48	2287.22	*d* 1 *v* 2 *c*	9.06	2294.41	*c* 1 *v* 3 *d*	8.67			

X Lacertæ was not recognized as a variable star and was used as a comparison star, when *V Lacertæ* was observed. Later it was found to vary and was then included in the working list, the previous comparisons being also utilized. The same comparison stars were used for both stars. Maximum (8.02) occurred at 2422113.50. The maximum is rounded but fairly well determined. Minimum (8.58) occurred at 2422117.52 (4.03 days after maximum). It is sharply defined. Compared with minima observed at the Laws and Dunsink Observatories it indicates the following expression for the occurrence of minima: 2416672.47 + $5.44294E + 0.000\,002\,15\,E^2$. The shape of the curve appears to be variable. The following are the twelve equidistant ordinates, beginning with maximum: 8.02, 8.04, 8.07, 8.21, 8.31, 8.36, 8.38, 8.39, 8.41, 8.56, 8.32, 8.08. They are rperesented by the formula:

$$\text{Mag.} = 8.26 - 0.21\cos(x - 31^\circ) - 0.08\cos(2x - 14^\circ) + 0.05\sin 3x + 0.04\cos(4x - 27^\circ).$$

0349.44	*v* 4 *a*	7.82	1499.38	*v* 2 *a*	8.00	1844.39	*a* 3 *v* 2½ *c*	8.40	2128.43	*a* 3 *v* 2½ *c*	8.39
0384.40	*v* 4 *c*	8.21	1503.33	*a* 2½ *v*	8.40	1845.34	*a* 2 *v* 2½ *c*	8.35	2131.45	*a* ½ *v*	8.22
0384.41	*a* 2 *v*	8.36	1508.31	*a* 1 *v* 2 *b*	8.34	1847.35	*a* 1 *v*	8.27	2131.50	*a* 1 *v*	8.27
0398.31	*v* 4 *c*	8.21	1565.38	*a* 1 *v*	8.27	1852.36	*v* 1½ *a*	8.05	2136.46	*v* = *a*	8.18
0515.36	*v* = *c*	8.57	1643.28	*a* 3½ *v* 1 *b*	8.55	1860.40	*a* 2 *v* 4½ *c*	8.30	2155.40	*a* 2 *v* 3 *c*	8.34
0534.25	*a* 1 *v* 6 *c*	8.24	1727.50	*v* 2 *a*	8.00	1862.30	*v* 3 *a*	7.91	2176.37	*a* 2 *v* 4 *c*	8.31
0548.27	*v* 3 *d*	8.72	1730.46	*v* = *a*	8.18	1864.39	*v* 3 *a*	7.91	2177.39	*v* = *c*	8.57
0670.42	*v* 3 *c*	8.30	1732.48	*v* 4 *a*	7.82	1865.31	*a* 1 *v*	8.27	2178.39	*v* 2 *a*	8.00
0721.34	*v* 5 *d*	8.54	1734.45	*a* 1½ *v*	8.31	1870.34	*a* 1½ *v* 3½ *c*	8.30	2180.38	*a* 1 *v*	8.27
0722.45	*v* 7 *c*	8.56	1741.45	*a* 1½ *v* 1 *c*	8.41	1873.29	*v* = *a*	8.18	2180.48	*v* ½ *a*	8.14
0750.40	*v* 1 *c*	8.48	1743.47	*v* 2 *a*	8.00	1875.29	*v* ½ *a*	8.14	2182.37	*a* 2 *v* 1½ *c*	8.39
0751.42	*v* 6 *f*	9.01	1744.45	*a* 1 *v*	8.27	1880.29	*v* 1 *a*	8.09	2184.42	*v* 2 *a*	8.00
0752.30	*v* 3 *a*	7.91	1745.46	*a* 1 *v*	8.27	1901.48	*v* 1 *a*	8.09	2186.36	*v* 2 *a*	8.00
0752.37	*v* 5 *c*	8.12	1746.42	*a* 1 *v* 3 *d*	8.38	1907.22	*v* 1½ *a*	8.05	2187.35	*a* 2 *v*	8.36
0752.45	*v* 5 *c*	8.12	1760.43	*v* 1 *a*	8.09	1951.34	*v* 1½ *a*	8.05	2192.37	*a* 2 *v* 3 *c*	8.34
0760.34	*v* 1 *c*	8.48	1761.45	*a* 1 *v*	8.27	1970.35	*v* = *b*	8.66	2198.41	*a* 1 *v*	8.27
0761.33	*v* = *c*	8.57	1767.49	*a* 1 *v* 3 *c*	8.28	1976.29	*b* 1 *v*	8.75	2210.41	*a* 2 *v* 2 *c*	8.38
0770.37	*v* 2 *c*	8.39	1768.43	*a* 1 *v*	8.27	2024.29	*a* 2 *v* 2 *c*	8.38	2211.33	*v* 1½ *a*	8.06
0779.28	*v* 3 *c*	8.30	1770.49	*v* 2 *a*	8.00	2093.46	*a* 2 *v* 2 *c*	8.38	2212.32	*v* 1 *a*	8.09
0785.30	*v* 2 *a*	8.00	1777.47	*a* 1 *v*	8.27	2096.48	*a* 1 *v* 3 *b*	8.30	2212.47	*v* 1 *a*	8.09
0791.30	*v* 2 *a*	8.00	1778.49	*a* 2 *v* 3 *c*	8.34	2098.48	*a* 1 *v* 4 *c*	8.26	2213.32	*v* 1 *a*	8.09
0804.38	*a* 3 *v* 5 *b*	8.36	1781.41	*v* 2 *a*	8.00	2099.49	*a* 1½ *v*	8.31	2214.34	*a* 1½ *v* 2 *c*	8.36
0887.29	*v* 2 *c*	8.39	1783.44	*a* 2 *v* 3 *c*	8.34	2100.47	*v* 1 *c*	8.48	2218.38	*a* 1 *v*	8.27
0892.25	*a* 3 *v* 3½ *c*	8.36	1784.42	*a* 3 *v* 1 *c*	8.47	2101.46	*a* 3 *v* 1 *c*	8.47	2219.33	*a* 2 *v* 3 *c*	8.34
0899.21	*a* 2 *v* 3 *c*	8.34	1787.42	*a* 2 *v* 4 *c*	8.31	2102.46	*a* 2 *v*	8.36	2223.41	*v* 2 *a*	8.00
0901.25	*a* 3 *v* 3 *c*	8.38	1793.47	*v* 1½ *a*	8.05	2107.46	*v* 2 *a*	8.00	2230.28	*a* 1 *v*	8.27
0903.26	*a* 3 *v* 2 *b*	8.47	1796.45	*a* 3 *v* 2 *c*	8.41	2115.45	*a* 2 *v* 1 *c*	8.44	2231.36	*a* 2 *v* 1½ *c*	8.39
0924.27	*a* 3 *v* 3 *c*	8.38	1812.39	*a* 2 *v* 3½ *c*	8.30	2117.45	*a* 2 *v* 4 *c*	8.31	2232.27	*a* 2 *v*	8.36
1036.43	*v* 2 *a*	8.00	1820.43	*v* 1 *a*	8.09	2118.45	*v* 2 *a*	8.00	2240.26	*a* 1 *v*	8.27
1036.53	*v* 3 *a*	7.91	1824.46	*v* 1½ *a*	8.05	2119.47	*v* 1½ *a*	8.05	2242.26	*a* 2 *v*	8.36
1070.38	*a* 3 *v* 2 *b*	8.47	1826.37	*v* = *a*	8.18	2120.41	*a* 1½ *v*	8.31	2245.26	*v* 2 *a*	8.00
1075.45	*a* 2 *v* 3 *c*	8.34	1827.35	*a* 1 *v*	8.27	2121.43	*a* ½ *v*	8.22	2247.28	*a* 1½ *v*	8.31
1076.38	*a* 2 *v* 1 *c*	8.44	1828.34	*a* 3 *v* 3 *c*	8.38	2123.45	*a* 3 *v* 2 *c*	8.41	2249.26	*v* 2 *a*	8.00
1096.37	*v* 2 *a*	8.00	1830.36	*v* 2 *a*	8.00	2124.45	*v* 2 *a*	8.00	2250.26	*v* 1½ *a*	8.05
1391.45	*v* = *a*	8.18	1838.37	*a* 1 *v* 3 *c*	8.28	2125.44	*v* 2 *a*	8.00	2251.26	*a* 1½ *v*	8.31
1176.33	*v* 2 *a*	8.00	1839.42	*a* 2 *v* 2 *c*	8.37	2126.43	*a* 1 *v*	8.27	2253.26	*v* 1 *a*	8.09
1176.37	*v* 3 *a*	7.91	1843.41	*a* 1½ *v* 3 *c*	8.31	2127.43	*a* 2 *v* 2½ *c*	8.35	2254.26	*v* 2 *a*	8.00

2258.26 α 2 v 2 c	8.38	2289.22 v 1½ α	8.05	2294.41 v 1 α	8.09	2298.47 v 2 α	8.00
2287.22 α 2 v 3 c	8.34	2292.39 α 1 v	8.27	2295.37 α 1 v 3½ c	8.27		

RS Andromedæ: The following observations are continued from *A. J.* 748. This is an irregularly variable star. Maxima occurred at 2422191 (7.4), and at 2422115 (7.6), and minima at 2422106 (8.7), and at 2422249 (8.5).

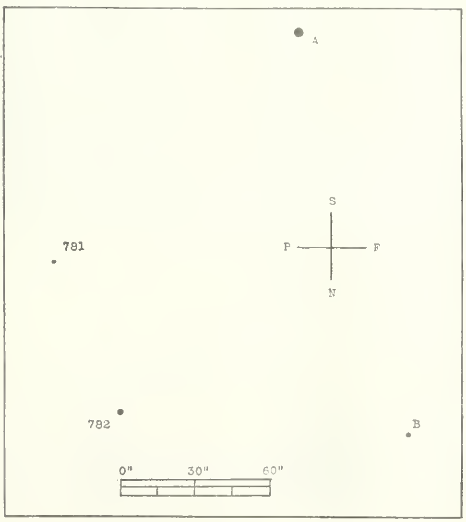
1951 c 2 v	8.40	2124 d 2 v 4 c	8.84	2213 α 1 v = b	7.80	2287 c 3 v 2 d	8.54
1959 c 2 v	8.40	2155 b 3 v 1½ c	8.07	2214 α 1 v 1 b	7.77	2294 v 1 c	8.08
1970 c 4 v 1 d	8.66	2176 v 1 α	7.63	2218 b 1 v 3 c	7.89	2312 b 2 v 3 c	7.95
1976 c 3 v 3 c	8.57	2177 v 3 α	7.40	2219 α 1 v	7.85	2340 b 1 v 3 c	7.89
1997 d 2 v 2 c	8.87	2180 v 2 α	7.52	2223 b 1 v	7.91	2343 b 1 v 2 c	7.93
2024 c 2 v 2 d	8.48	2182 v 2 α	7.52	2230 b 3 v 1 c	8.09	2355 v 1 c	8.08
2057 c 1 v	8.29	2184 v 3 α	7.40	2242 c 4 v 2 d	8.58	2363 v = c	8.18
2096 c 4½ v 1 d	8.67	2192 α′ 3 v 3 α	7.40	2245 c 3 v 3 d	8.48	2369 v = c	8.18
2098 c 3 v 1 d	8.63	2198 α′ 3 v 3 α	7.40	2249 c 4 v 4 d	8.48	2379 c 1 v	8.29
2099 c 3 v 2 d	8.54	2210 α′ 3½ v 1½ α	7.57	2253 c 2 v 2 d	8.48	2392 c = v	8.18
2107 c 5 v 3 d	8.56	2211 α′ 3½ v 1 α	7.63	2282 c 3 v 5 d	8.40	2415 v 1 α	7.63
2117 d 1 v 3 c	8.82	2212 α′ 5 v 1 α	7.63				

α′ is *A. S. V.* No. 5.

MAX WOLF'S TWO SMALL PROPER-MOTION STARS IN *SERPENS* (*A. N.* 4981)

By E. E. BARNARD.

In *A. N.* 4981 Dr. Max Wolf calls attention to his discovery of two faint stars with large proper-motions. The two are (according to Wolf) moving in the same direction but with slightly different velocities. The distance between them is more than one minute of arc.



	Mag.	P.M.	Direction
Wolf No. 781	16	1″.54	180°
782	13.5	1 .43	180

According to the above the fainter star has the larger motion. It is more than probable that these two stars are in some way physically connected, and if so they are probably relatively near to us. The south preceding star is the fainter. It cannot be brighter than the 16th magnitude; under ordinary conditions it is a rather difficult object to measure. I have made the following visual observations of these objects. The north following and brighter one was compared with an 11 or 12 magnitude star (which we will call *A*) south following it.

782 ($13^m.5$) and *A*

1919.479	155°.41	171″.65	(1 *n.*)
1920.483	155 .08	170 .35	(6 5 *n.*)

782 and 781 (16^m)

1920.484	201°.41	67″.63	(4 *n.*)

At the observations of 1919 the conditions were not good enough to measure the smaller star.

On 1920 July 13 the star *A* was compared with

Leipzig A. G. C. 7123, from which the following position of it was obtained:

$$1920.0 \quad \alpha \; 15^h\,53^m\,22^s.46\,, \quad \delta + 5^\circ\,20'\,7''.6.$$

The micrometer measures with this star give the position of 782:

$$1920.0 \quad \alpha \; 15^h\,53^m\,17^s.65\,, \quad \delta + 5^\circ\,22'\,42''.8.$$

Correction for motion in declination has been applied.

The brighter star of the two (the north following one) was compared with a slightly less bright star, following, which we will call *B*.

782 and *B*

1920.569 85°.69 117″.18 (6*n*)

Yerkes Observatory, Williams Bay, Wisconsin,
1920, August 17.

NOTE ON THE PROPER-MOTIONS OF *B. D.* +1°4134 AND *B. D.* +1°4135,

By FRANK SCHLESINGER.

In preparing printer's manuscript for the photographic catalog of equatorial stars compiled by means of a doublet lens, the writer noticed that the photographic positions of these two stars differ largely and in the same sense from those given in the Albany zone of the *A. G. Catalog*. The two stars are 2′ 42″ apart, and their visual magnitudes are 8.5 and 8.8. Their spectra (kindly communicated by the Harvard observers in advance of the publication of the *New Draper Catalog*) are both *K0*.

The photographic positions, reduced to the equinox 1875.0, are:

	B. D. +1° 4134
Preceding Plate	$19^h\,47^m\,55^s.40,\ +1^\circ\,37'\,31''.6$
Following Plate	$19^h\,47^m\,55^s.40,\ +1^\circ\,37'\,31''.9$

	B. D. +1° 4135
Preceding Plate	$19^h\,48^m\;\;6^s.18,\ +1^\circ\,37'\,22''.7$
Following Plate	$19^h\,48^m\;\;6^s.15,\ +1^\circ\,37'\,22''.3$

The epoch of these observations is 1914.5 in each case.

The Albany positions for the same equinox are:

$19^h\,47^m\,55^s.45,\ +1^\circ\,37'\,41''.0$

$19^h\,48^m\,6^s.24,\ +1^\circ\,37'\,31''.8$

The epochs of observation are 1880.1 and 1879.7. The proper-motions are therefore

$-''.023$ in R. A.	$-''.269$ in Declination
$-''.033$	$-''.267$

Both these stars are included in the recent catalog published by the Cincinnati Observatory, where the following proper-motions are given:

B. D. +1° 4134	$-''.013$ in R. A.	$-''.299$ in Decl.
B. D. +1° 4135	.000	$-''.29$

It is therefore certain that these two stars form another of those interesting systems in which the linear separations are so great as to make their mutual attractions very feeble; but in which, nevertheless, large common proper-motions are present. A number of such cases have recently come to light. A systematic search of existing catalogs for additional pairs would be well worth while, and a study of their motions as a whole would probably lead to important conclusions. The radial velocities and the parallaxes of these objects should also be determined.

Yale University Observatory,
August 10, 1920.

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OCCULTATIONS BY THE *MOON* AND *VENUS*,

OBSERVED WITH THE 26-INCH AND 12-INCH EQUATORIALS OF THE U. S. NAVAL OBSERVATORY

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Date	Object	Phen	26-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem.	12-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem.
	By the *Moon*													
1919			h m s	h m s					h m s	h m s				
Aug. 7	14 *Sagittarii*	DD	20 38 28.7	11 35 53.7	*p*	178	Bn	1	. . . . . .	. . . . . .		. . .	. .	. .
11	c^1 *Capricorni*	DB	20 43 27.7	11 25 8.2	*f*	178	Bn	2	20 43 27.8	11 25 8.3	*f*	160	B	4
11	c^1 *Capricorni*	RD	22 1 14.0	12 42 41.7	*f*	178	Bn	3	22 1 14.2	12 42 42.0	*f*	160	B	5
18	ω *Tauri*	DB	0 49 2.2	15 2 31.1	*f*	178	Bn	. .	. . . . . .	. . . . . .		. . .	. .	. .
18	ω *Tauri*	RD	1 53 9.7	16 6 28.1	*f*	183	Bn		1 53 10.0	16 6 28.4	*f*	115	B	5
Sept. 5	267 *B. Sagittarii*	DD	20 40 58.5	9 44 21.7	*p*	388	Bn		. . . . . .	. . . . . .		. .		. .
5	267 *B. Sagittarii*	RB	21 56 49.8	11 0 0.6	*rp*	178	Bn		. . . . . .	. . . . . .		. . .	. .	. .
16	χ^2 *Orionis*	DB	2 29 5.6	14 18 16.8	*rp*	178	Hl	6	2 29 5.2	14 48 16.4	*rp*	160	B	8
16	χ^2 *Orionis*	RD	3 18 25.6	15 37 28.7	*f*	183	Hl	7	3 18 25.6	15 37 28.7	*p*	115	B	9
Oct. 6	κ *Aquarii*	DD	. . . . . .	. . . . . .		. .			19 1 42.8	6 3 29.1	*p*	115	B	10
6	κ *Aquarii*	RB	. . . . . .	. . . . . .					20 5 24.5	7 7 0.5	*p*	160	B	11
6	207 *B. Aquarii*	DD	21 16 51.8	8 18 16.1	*f*	178	Hl	5	21 16 51.8	8 18 16.0	*p*	115	B	9
6	207 *B. Aquarii*	RD	. . . . . .	. . . . . .		. .	. .		22 30 1.8	9 31 11.0	*p*	160	B	12
Nov. 14	14 *Sextantis*	DB	. . . . . .	. . . . . .		. .	. .	. .	5 6 31.0	13 33 17.9	*rp*	160	B	8
14	14 *Sextantis*	RD	. . . . . .	. . . . . .		. .	. .		6 12 16.5	14 39 22.6	*p*	115	B	9
Dec. 10	60 *Cancri*	DB	6 19 18.2	13 4 9.1	*p*	178	Hl	11	6 19 19.4	13 4 10.6	*f*	115	B	15
10	60 *Cancri*	RD	7 38 7.2	14 22 15.6	*f*	183	Hl	5	7 38 7.1	14 22 15.7	*f*	115	B	5
1920 Jan. 5	162 *B. Geminorum*	DB	9 45 45.2	11 47 18.9	*f*	178	Hl	. .	9 45 44.7	11 47 18.4	*f*	160	B	1
5	162 *B. Geminorum*	RD	. . . . . .	. . . . . .		. .	. .	. .	10 33 51.9	15 35 17.7	*f*	160	B	16
28	124 *B. Arietis*	DD	8 49 15.8	12 21 2.8	*p*	183	Hl	7	8 49 15.9	12 21 2.8	*p*	160	B	9
31	*Anon.* (6m)	DD	. . . . . .	. . . . . .		. .	. .		7 1 34.0	10 21 21.1	*f*	160	B	10
31	*Anon.* (6m)	RB	. . . . . .	. . . . . .					8 0 33.2	11 20 10.5	*f*	160	B	17
31	*B. D.* +19° 1110	RB	7 17 35.3	10 37 19.6	*g*	183	Hl	39	. . . . . .	. . . . . .		. . .	. .	. .
31	χ^1 *Orionis*	DD	. . . . . .	. . . . . .		. .		.	7 42 21.1	11 2 1.7	*f*	160	B	9
31	χ^1 *Orionis*	RB	. . . . . .	. . . . . .		. .			8 32 1.0	11 51 33.1	*f*	160	B	22
31	64 *Orionis*	DD	11 47 44.2	15 6 44.3	*f*	183	Hl	19	. . . . . .	. . . . . .		. . .	. .	
Feb. 2	1 *Cancri*	DD	7 5 6.9	10 17 1.4	*g*	183	Hl	40	7 5 7.1	10 17 1.6	*f*	160	B	9
2	1 *Cancri*	RB	8 18 20.8	11 30 3.1	*f*	183	Hl	18	8 18 21.3	11 30 6.8	*f*	160	B	20
11	λ *Libræ*	DB	15 19 16.2	17 54 26.7	*f*	183	Hl	. .	15 19 16.0	17 54 26.4	*p*	160	B	4
11	λ *Libræ*	RD	16 53 7.7	19 28 2.8	*f*	183	Hl	21	. . . . . .	. . . . . .		. . .	. .	. .

Date	Object	Ph.	26-Inch W. Sid. T.	26-Inch W. M. T.	See'g	Pow'r	Obs	Rem	12-Inch W. Sid. T.	12-Inch W. M. T.	See'g	Pow'r	Obs.	Rem
			By the *Moon*											
			h m s	h m s					h m s	h m s				
Feb. 26	282 *B. Tauri*	DD	9 25 46.0	11 2 55.8	*p*	183	Hl	23	9 25 46.2	11 2 55.9	*p*	115	B	10
26	*A.G. Berlin* A 1228	DD	9 34 13.3	11 11 21.7	*p*	183	Hl	23	9 34 13.5	11 11 21.9	*p*	115	B	9
Mar. 1	84 *B. Cancri*	DD	9 12 28.5	10 33 56.8	*f*	183	Hl	9	...	...	...	...	...	...
1	84 *B. Cancri*	RB	10 25 45.2	11 47 1.4	*f*	183	Hl	24	...	...	...	...	...	...
2	ω *Leonis*	DD	8 53 47.3	10 11 22.7	*f*	183	Hl	25	8 53 47.3	10 11 22.8	*f*	160	B	26
2	ω *Leonis*	RB	10 12 54.0	11 30 16.5	*f*	183	Hl	24	10 12 57.8	11 30 20.3	*f*	160	B	27
29	κ *Cancri*	DD	...	...	...	...	...	...	7 42 4.7	7 13 42.4	*p*	115	B	28
29	κ *Cancri*	RB	...	...	...	...	...	...	9 4 39.8	8 36 4.0	*p*	160	B	29
30	14 *Sextantis*	DD	12 6 51.3	11 33 49.8	*f*	183	Hl	30	12 6 51.6	11 33 50.0	*p*	115	B	5
30	14 *Sextantis*	RB	13 18 51.9	12 45 38.5	*p*	183	Hl	31	13 18 47.6	12 45 34.2	*vp*	160	B	32
Apr. 2	χ *Virginis*	DD	13 50 35.1	13 5 28.8	*p*	178	Hl	..	13 50 35.0	13 5 28.7	*p*	160	B	5
2	χ *Virginis*	RB	14 21 47.1	13 36 35.7	*p*	183	Hl	33	...	...	...	...	...	...
May 3	41 *Libra*	DB	12 36 36.0	9 49 48.7	*vp*	178	Hl	34	12 36 34.4	9 49 47.1	*vp*	160	B	13
3	41 *Libra*	RD	13 53 4.7	11 6 4.9	*p*	183	Hl	.	13 53 5.0	11 6 5.2	*vp*	160	B	5
27	ψ *Virginis*	DD	12 45 10.5	8 24 0.0	*f*	183	Hl	..	...	...	...	...	...	...
31	58 *G. Scorpii*	DD	17 28 31.8	12 50 51.2	*f*	183	Hl	35	...	...	...	...	...	...
31	58 *G. Scorpii*	RB	18 26 14.0	13 48 24.0	*g*	183	Hl	36	...	...	...	...	...	...
June 9	λ *Piscium*	DB	18 49 28.4	13 36 11.3	*vp*	178	B	8	...	...	...	...	...	...
9	λ *Piscium*	RD	19 17 55.2	14 4 33.5	*p*	183	B	9	...	...	...	...	...	...
27	β *Scorpii*	DD	19 19 46.5	12 55 38.1	*vp*	178	Hl	37	...	...	...	...	...	...
27	56 *B. Scorpii*	DD	19 20 49.8	12 56 41.2	*vp*	178	Hl	..	...	...	...	...	...	...
			By *Venus*											
Jan. 4	*Bordeaux* (1890) 4649	RD	...	...	...	...	...	...	13 16 48.8	18 21 43.9	*p*	115	B	38

All observations were recorded on chronograph. Occulting bars were attached to eyepieces of powers 178 and 160.

Ph.: DD = disappearance dark limb; DB = disappearance bright limb; RD = reappearance dark limb; RB = reappearance bright limb.

Obs.: Hl = A. Hall; Bn = H. E. Burton; B = Ernest Clare Bower.

Rem.: (1) Star very faint. Clouds. (2) Gradual. Haze. (3) Haze. (4) $\pm 2^s$. (5) Late $0^s.2$. (6) Uncertain. (7) Dark limb visible. (8) $\pm 6^s$. (9) Late $0^s.1$. (10) Late $0^s.15$. (11) Late $3^s \pm 2^s$. (12) Late $6^s \pm 3^s$. Star very faint when first seen. (13) $\pm 3^s$. (14) Early. (15) $\pm 1^s$. (16) Late 0^s to 10^s. (17) Uncertain whether an observation of the reappearance. This object has not been identified. (18) Late. (19) Uncertain whether real disappearance. Clouds. (20) Late $2\frac{1}{2}^s$. (21) Uncertain whether real reappearance. Daylight. (22) Late $1\frac{1}{2}^s$. (23) Windy. (24) Late 1^s. (25) Partial disappearance $2^s.7$ earlier. (26) Late $0^s.15$. $2^s.7$ before disappearance star lost about half its light during about $\frac{1}{2}^s$, then brightened perhaps to normal. Sky apparently clear. (27) Late $7^s \pm 2^s$. (28) Late $0^s.1$. Clouds. (29) Late $3^s \pm 1\frac{1}{2}^s$. (30) Late $0^s.1$. Star fuzzy. (31) Late 3^s. (32) Late $5^s \pm 3^s$. (33) Late. Sidereal time may be 1^m earlier. (34) Early several seconds. (35) Uncertain by 1^s. Star faint. Clouds. (36) Late 2^s. (37) First disappearance $2^s.6$ earlier. (38) Certainly late 10^s. Possibly late $\frac{1}{2}^m$ to $1\frac{1}{2}^m$ or more. (39) Late. Eyepiece fogged. (40) Eyepiece fogged.

U. S. Naval Observatory, Washington, D. C.,
1920, July 15.

NOTE ON SOME FORMULAS USED BY G. W. HILL IN HANSEN'S METHOD,

By HANS OSTEN.

Mr. Innes suggested that I comment on his note (*A. J.* 731) upon the above subject, so I beg leave to state the following:

The difficulty of reproducing Hill's formula for $r^2 \frac{\partial^2 T}{\partial r^2}$ seems to arise principally from the fact, that in the *Astronomical Papers*, Vol. IV, to which all pages cited here refer, there has been made no distinction in the notation between total and partial differentiation. Therefore it is not permissible to interchange the order of differentiation with respect to r and g without making the necessary allowance. We shall let ∂ = partial, d = total differential. Moreover it must be kept in mind that T is originally a function of the two independent variables f and r. If a function of r has been replaced *e. g.* by a function of f, then this substitution must be made after differentiation.

Hill calls:

$$r \frac{\partial T}{\partial r} = B,$$

we want

$$r^2 \frac{\partial^2 T}{\partial r^2} = r \frac{\partial B}{\partial r} - B,$$

but for greater clearness we start with the original value of T, page 200, and put

$$T = m \frac{\partial \Omega}{\partial f} + n r \frac{\partial \Omega}{\partial r}$$

so

$$\frac{\partial T}{\partial r} = \frac{\partial m}{\partial r} \frac{\partial \Omega}{\partial f} + \frac{\partial n}{\partial r} r \frac{\partial \Omega}{\partial r} + m \frac{\partial^2 \Omega}{\partial f \partial r} + n \left(r \frac{\partial^2 \Omega}{\partial r^2} + \frac{\partial \Omega}{\partial r} \right)$$

$$\frac{\partial^2 T}{\partial r^2} = \frac{\partial^2 m}{\partial r^2} \frac{\partial \Omega}{\partial f} + 2 \frac{\partial m}{\partial r} \frac{\partial^2 \Omega}{\partial f \partial r} + \frac{\partial^2 n}{\partial r^2} r \frac{\partial \Omega}{\partial r} + 2 \frac{\partial n}{\partial r} \left(r \frac{\partial^2 \Omega}{\partial r^2} + \frac{\partial \Omega}{\partial r} \right) + m \frac{\partial^3 \Omega}{\partial f \partial r^2} + n \left(r \frac{\partial^3 \Omega}{\partial r^3} + 2 \frac{\partial^2 \Omega}{\partial r^2} \right).$$

In order to facilitate the numerical computation the derivatives with respect to f are replaced by total differentials with respect to g, viz.

$$\frac{d \Omega}{d g} = \frac{\partial \Omega}{\partial f} \frac{d f}{d g} + \frac{\partial \Omega}{\partial r} \frac{d r}{d g}$$

$$\frac{d}{d g} \cdot \left(r \frac{\partial \Omega}{\partial r} \right) = \frac{\partial \Omega}{\partial r} \frac{d r}{d g} + r \frac{\partial^2 \Omega}{\partial f \partial r} \frac{d f}{d g} + r \frac{\partial^2 \Omega}{\partial r^2} \frac{d r}{d g}$$

$$\frac{d}{d g} \cdot \left(r^2 \frac{\partial^2 \Omega}{\partial r^2} \right) = 2r \frac{\partial^2 \Omega}{\partial r^2} \frac{d r}{d g} + r^2 \frac{\partial^3 \Omega}{\partial f \partial r^2} \frac{d f}{d g} + r^2 \frac{\partial^3 \Omega}{\partial r^3} \frac{d r}{d g}.$$

Substituting the elliptical values:

$$\frac{d f}{d g} = \frac{a^2 \cos \varphi}{r^2}, \quad \frac{d r}{d g} = \frac{ae \sin f}{\cos \varphi}$$

and solving the equations we have

$$\frac{\partial \Omega}{\partial f} = \frac{r^2}{a^3 \cos \varphi} a \frac{d \Omega}{d g} - \frac{re \sin f}{a^2 \cos^2 \varphi} a r \frac{\partial \Omega}{\partial r}$$

$$\frac{\partial^2 \Omega}{\partial f \partial r} = \frac{r}{a^3 \cos \varphi} \frac{d}{d g} \cdot \left(a r \frac{\partial \Omega}{\partial r} \right) - \frac{re \sin f}{a^2 \cos^2 \varphi} \left(a r \frac{\partial^2 \Omega}{\partial r^2} + a \frac{\partial \Omega}{\partial r} \right)$$

$$\frac{\partial^3 \Omega}{\partial f \partial r^2} = \frac{1}{a^3 \cos \varphi} \frac{d}{d g} \cdot \left(a r^2 \frac{\partial^2 \Omega}{\partial r^2} \right) - \frac{e \sin f}{a^2 \cos^2 \varphi} \left(a r^2 \frac{\partial^3 \Omega}{\partial r^3} + 2ar \frac{\partial^2 \Omega}{\partial r^2} \right).$$

Further we put

$$\frac{m r^2}{a^3 \cos \varphi} = A \quad , \quad \frac{n}{a} - \frac{mre \sin f}{a^2 \cos^2 \varphi} = B$$

$$\frac{\partial m}{\partial r} \frac{r^3}{a^3 \cos \varphi} = M \quad , \quad \frac{\partial n}{\partial r} \frac{r}{a} - \frac{\partial m}{\partial r} \frac{r^2 e \sin f}{a^2 \cos^2 \varphi} = N$$

and from

$$\frac{\partial m}{\partial r} = - \frac{a}{\cos \varphi} 2 \frac{s}{r^2} \cos (f - \omega)$$

and

$$\frac{\partial n}{\partial r} = - \frac{a}{\cos \varphi} 2 \frac{s}{r^2} \sin (f - \omega)$$

we get

$$\frac{\partial^2 m}{\partial r^2}\,\frac{r^4}{a^3 \cos\varphi} = -2M\,.$$

$$\frac{\partial^2 m}{\partial r^2}\,\frac{r^2}{a} - \frac{\partial^2 m}{\partial r^2}\,\frac{r^3 e \sin f}{a^2 \cos^2\varphi} = -2N\,.$$

After the necessary reductions, introducing

$$\frac{d}{d\,g}\cdot\left(a\,r^2\,\frac{\partial^2\,\Omega}{\partial\,r^2} + a\,r\,\frac{\partial\,\Omega}{\partial\,r}\right) - \frac{d}{d\,g}\cdot\left(a\,r\,\frac{\partial\,\Omega}{\partial\,r}\right)$$

$$= \frac{d}{d\,g}\cdot\left[a\left(\frac{r\,\partial}{\partial\,r}\right)^2\Omega\right] - \frac{d}{d\,g}\cdot\left(a\,r\,\frac{\partial\,\Omega}{\partial\,r}\right)$$

instead of

$$\frac{d}{d\,g}\cdot\left(a\,r^2\,\frac{\partial^2\,\Omega}{\partial\,r^2}\right)$$

and calling

$$a\,r\left(r^2\,\frac{\partial^3\,\Omega}{\partial\,r^3} + 3r\,\frac{\partial^2\,\Omega}{\partial\,r^2} + \frac{\partial\,\Omega}{\partial\,r}\right) = a\left(r\,\frac{\partial}{\partial\,r}\right)^3\Omega$$

we get, using the V of page 199

$$r^2\,\frac{\partial^2\,T}{\partial\,r^2} = A\,\frac{d}{d\,g}\cdot\left[a\left(\frac{r\,\partial}{\partial\,r}\right)^2\Omega\right] + B\,a\left(\frac{r\,\partial}{\partial\,r}\right)^3\Omega - V$$

$$+ 2\,M\,\frac{d}{d\,g}\cdot\left(a\,r\,\frac{\partial\,\Omega}{\partial\,r}\right) + 2\,N\,a\,r\left(r\,\frac{\partial^2\,\Omega}{\partial\,r^2} + \frac{\partial\,\Omega}{\partial\,r}\right)$$

$$- 2\,M\,a\,\frac{d\,\Omega}{d\,g} \qquad\qquad - 2\,N\,a\,r\,\frac{\partial\,\Omega}{\partial\,r}$$

which is equivalent to HILL's formula page 341.

The second point refers to separating the perturbation ν into a constant term c and the purely periodic remainder, page 20 21. If the constant c is introduced from the first approximation on, then parts of the second order perturbations are already included in the first order terms, and so on. The equations for the second and third order terms are to be modified correspondingly (page 200). In the perturbative function only the quantities r and r', and their function Δ have the increments $(1 + c)$ and $(1 + c')$, and if the computation yields, for example, $\frac{a'(1 + c')}{\Delta}$, instead of $\frac{a'}{\Delta}$, this factor $(1 + c')$ must be cancelled, which has been done by giving μ and μ' (page 66) the multipliers required. It is readily seen that on the same page $a\ \Omega$ and $ar.\ \frac{d\,\Omega}{d\,r}$ are correct and on page 522 the computation of the third coördinate has been put right.

As to the third point mentioned in INNES' Paper we have only to state that HILL retains the second order in the sine. As there are no first order terms in the $\sin(1 - f - \pi - T)$, the cosine of this arc is unity, neglecting quantities of the fourth order. So $1 = f + \pi + T - \frac{1}{2}s\,\frac{d\,s}{d\,v}$, page 518, is really a legitimate approximation.

The error in HILL's Theory of *Jupiter* and *Saturn*, pointed out by MR. INNES in No. 688 of this *Journal* and found independently by myself (see *Astr. Nachr. Bd.* 210, No. 5025) fortunately proves to be practically negligible. I have computed the largest terms resulting for $\Delta n'\ \delta^3\ z'$ for *Saturn* and found:

$\Delta n'\ \delta^3\ z',\ T = 1$ jul. century

Arg. i' g'	i g	sin	T	cos	T
			"		"
+1	0		+0.0010		+0.0039
		"		"	
+4	−2	+0.0049	−0.0016	−0.0152	−0.0019
+5	−2	−0.0152	−0.0102	−0.0165	+0.0068
+6	−2	+0.0035	+0.0012	+0.0036	−0.0012

so that no correction to that celebrated work is required.

Leipzig, April 20, 1920

NOTE BY R. T. A. INNES

I accept HERR OSTEN's findings on each of the four points. I wrote to him because his work on the Minor planet 117 VALENTINE showed that he was a master of HANSEN's Method of computing perturbations and that HILL's work on *Jupiter* and *Saturn* was also known to him. Although it is a matter of no importance, I would like to say that when I wrote HERR OSTEN I told him that I had already overcome my first difficulty. I had fallen into error by confusing

$$\left(r\,\frac{\partial}{\partial\,r}\right)^2 \quad\text{with}\quad r^2\,\frac{\partial^2}{\partial\,r^2}$$

or what is the same thing

$$\left(a\frac{\partial}{\partial a}\right)^2 \quad \text{with} \quad a^2\frac{\partial^2}{\partial a^2}$$

whereas

$$\left(a\frac{\partial}{\partial a}\right)^2 = a\frac{\partial}{\partial a} + a^2\frac{\partial^2}{\partial a^2}$$

(See NEWCOMB, *Astr. Papers*, V. p. 6). With HERR OSTEN, I agree that separate signs should be used for partial and complete differentiation.

Arg. $i'g'+ig$	$\frac{a_0}{\mu}\left(r\frac{d}{dr}\right)^3\Omega$				$\frac{a'_0}{\mu'}\left(r'\frac{d}{dr'}\right)^3\Omega'$			
	cos		sin		cos		sin	
	HILL	Corrected	HILL	Corrected	HILL	Corrected	HILL	Corrected
i' i								
0 0	−1.820	+2.584	....	.....	− 7.663	− 6.335	....	....
0 −1	−0.184	−0.516	−0.308	−0.597	+ 1.171	+ 0.967	+ 0.888	+ 0.695
0 −2	−0.023	−0.035	+0.013	+0.064	+ 0.068	+ 0.061	+ 0.135	− 0.120
0 −3	+0.002	+0.002	+0.003	+0.002	− 0.004	− 0.003	− 0.004	− 0.004
1 +1	−0.065	−0.119	+0.021	+0.031	+ 0.219	+ 0.184	− 0.054	− 0.048
1 0	+0.151	+0.710	+0.137	+0.836	− 1.579	− 1.282	− 2.043	− 1.743
1 −1	−0.339	+0.944	+1.593	−4.712	− 3.685	− 3.303	+18.109	+16.199
1 −2	−0.296	−0.375	+0.198	+0.268	+ 0.499	+ 0.391	− 0.132	− 0.048
1 −3	+0.024	+0.033	+0.028	+0.035	− 0.058	− 0.053	− 0.029	− 0.024
2 −1	+0.477	+1.375	+0.070	−0.620	− 3.137	− 2.790	+ 1.798	+ 1.508
2 −2	−1.625	−5.464	−0.663	−2.305	+13.083	+11.913	+ 5.559	+ 5.068
2 −3	+0.114	+0.092	+0.120	+0.073	− 0.090	− 0.066	+ 0.045	+ 0.091
3 −1	+0.129	+0.298	+0.097	+0.098	− 0.625	− 0.547	− 0.146	− 0.150
3 −2	−0.027	−0.567	−1.038	−1.965	+ 1.489	+ 1.282	+ 4.058	+ 3.721
3 −3	−1.941	−3.415	+2.882	+4.980	+ 7.037	+ 6.594	−10.183	− 9.538
3 −4	−0.109	−0.208	−0.069	−0.042	+ 0.508	+ 0.518	+ 0.008	+ 0.005
4 −2	+0.199	+0.218	−0.224	−0.420	− 0.344	− 0.339	+ 0.848	+ 0.766
4 −3	−1.622	−2.439	+0.029	+0.339	+ 4.601	+ 4.314	− 0.928	− 0.814
4 −4	+2.794	+3.826	+2.881	+3.999	− 6.912	− 6.591	− 7.300	− 6.962
4 −5	−0.083	−0.075	+0.308	+0.410	+ 0.087	+ 0.088	− 0.768	− 0.762
5 −2	+0.063	+0.083	−0.009	−0.032	− 0.143	− 0.134	+ 0.075	+ 0.064
5 −3	−0.335	−0.522	−0.329	−0.371	+ 0.996	+ 0.921	+ 0.577	+ 0.564
5 −4	−0.146	−0.030	+2.011	+2.652	− 0.167	− 0.124	− 4.643	− 4.394
5 −5	+3.176	+3.937	−1.994	−2.437	− 6.566	− 6.334	+ 4.000	+ 3.860
5 −6	+0.403	+0.486	+0.153	+0.164	− 0.814	− 0.803	− 0.234	− 0.233
6 −4	−0.163	−0.529	+0.418	+0.575	+ 0.803	+ 0.779	− 1.026	− 0.966
6 −5	+2.096	+2.553	+0.446	+0.453	− 4.150	− 3.996	− 0.583	− 0.583
6 −6	−1.044	−1.193	−2.925	−3.402	+ 1.808	+ 1.759	+ 5.294	+ 5.147
6 −7	+0.226	+0.247	−0.398	−0.456	− 0.359	− 0.356	+ 0.713	+ 0.703
7 −5	+0.435	+0.551	+0.577	+0.652	− 0.925	− 0.882	− 0.972	− 0.945
7 −6	+0.728	+0.799	−1.902	−2.202	− 1.127	− 1.105	+ 3.383	+ 3.283
7 −7	−2.358	−2.637	+0.285	+0.305	+ 3.881	+ 3.798	− 0.415	− 0.406
8 −7	−1.524	−1.706	−0.901	−0.983	+ 2.502	+ 2.442	+ 1.390	+ 1.364
8 −8	−0.145	−0.170	+1.673	+1.825	+ 0.283	+ 0.277	− 2.582	− 2.531

With regard to the 4th point: — HILL's error in obtaining the third derivatives of the Perturbing Functions does not seem to have much influence as the terms of the third order of the masses arising from the perturbations of the radii-vectores mainly cancel out. HERR OSTEN has actually computed some of these terms for *Saturn* and his paper will, I understand, appear in the *Astron. Nachr.* The results are summarized above and show that the secular terms are not appreciably affected.

I give a short comparison of HILL's values and the corrected values of the Perturbing Functions. (See HILL, pp. 345–6).

This table shows that whilst the quantities for *Saturn* are only altered by percentages, many of those for *Jupiter* are entirely wrong. It would be dangerous to say off-hand how the final result is affected, but the change will not be large. The portions contributed by the various perturbations for the secular terms in t and for the chief part of the great inequality are as follows: —

From	0, 0, 0	1, 0, −1	0, 5, −2	
	cos	cos	sin	cos
	$''$	$''$	$''$	$''$
$n\delta^2 z$	−0.0000551	+0.0000052	+0.0006399	+0.0015326
$\delta\nu$	− 128	+ 8	+ 4766	+ 11381
$n'\delta^2 z'$	− 1186	− 791	− 225	+ 2158
$\delta\nu'$	− 415	+ 109	+ 4096	+ 9613
$(n\delta z)^2$	+ 64	− 52	− 1827	− 4691
$(n\delta z)\,(n'\delta z')$	− 52	− 98	− 3418	− 9403
$(n'\delta z')^2$	− 921	+ 1557	+ 3366	+ 7807
$(n\delta z)\,\nu$	+ 37	− 18	− 1234	− 3257
$(n'\delta z')\,\nu$	+ 153	− 119	− 3058	− 7671
$(n\delta z)\,\nu'$	+ 173	− 68	− 245	− 1270
$(n'\delta z')\,\nu'$	− 316	− 258	− 1538	− 3436
ν^2	+ 1	+ 12	+ 55	+ 80
$\nu\nu'$	+ 88	− 79	+ 524	+ 648
ν'^2	+ 219	− 268	+ 575	+ 446

(From HILL, pp. 373 to 380).

It will be seen that the last three lines which are the only ones affected are not the predominant ones and it is quite unlikely that the correct values will seriously modify the final values.

The calculation should however be made. If we build up

$$r^2 \frac{d^2}{d\,r^2}\, T \text{, etc.}$$

(HILL, p. 351) we have for 1, 0, − 1:

HILL	+216″.02	−0″.46
Corrected	− 66 .4	−0 .46

For 1, 0, −2	HILL	+0.95	+2.74	−2″.60	+2″.06	+3″.58	− 9″.59
	Corrected	+4.83	−6.53	−6″.48	+11.33	+7 .46	−18 .86

(Consult the last line of p.351 for the meaning of the last sets of figures.

These changes look important enough, but they may really signify nothing.

If in the table above, we look for the coefficient of ν^2 in (0, 0, 0) we see it is only $+0''.0000001$ which is an insignificant quantity, but it is actually the sum of about 30 terms positive and negative which nearly cancel each other. At the moment I cannot lay my hands on my work but by memory the result was something like this: —

$$\left.\begin{array}{l} +0.00001798 \\ -0.00001784 \end{array}\right\} = +0''.00000014$$

Such a result can have little value. JACOBI laid down the dictum that the method which gives a result as the differences of two large numbers is not a good method. In HERR OSTEN's paper in *A. N.* 5025, col. 133 he points out that the second order terms involving three anomalies lead to an almost endless series of components rising now and then to 0″.4 in the case of VALENTINE as disturbed by *Jupiter* and *Saturn*, and in col. 137 he points out that the magnitude of the quantity F $(0s)$ is quite uncertain as it consists of 313 products some of considerable magnitude which nearly cancel one another: the final result being $+11711 - 11369 = \Sigma\, 342$.

I defer further remarks which might take some time to prepare as tending to unduly delay HERR OSTEN's paper.

Johannesburg, May 25, 1920.

THE VARIABLE STAR *R SCUTI*.

By ELIAS BRESON.

I have observed *R Scuti* ($18^h\ 39^m\ 45^s$, $-5°\ 51'.4$ 1855.0) at Helsingor, Denmark, with my 30mm Zeiss-binocular "Silvarem," 6×. The observations of Oct. 15 to 30 and Nov. 9, 13, 16, 1919, were made with a Busch binocular à prism, "Terlux," 45mm, 10×. The companion stars were:

Desig.	Name	R.H.P.	R.A.	Dec.	Mag.	Auth.
			h m	° ′		
β	β *Scuti*	7063	18 41.9	−4 51	4.47	R.H.P.
η	η *Scuti*	7149	18 51.7	−5 58	5.04	R.H.P.
a	....	7083	18 44.3	−6 01	6.22	R.H.P.
b	−6° 4913	....	18 43.3	−6 07	6.53	H.A. 45
h	*h Aquilæ*	....	18 59.7	−4 11	5.70	......

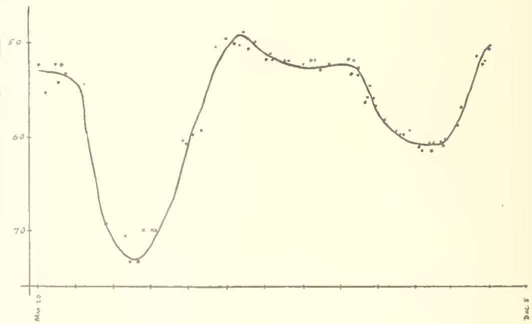
Each step equaled $0^m.1$, except in the observations of May 8, 9, 11, 1919 where it is $0^m.2$. I have not corrected for extinction. It will be necessary to subtract $0^m.27$ from all magnitudes. All estimates are given the same weight.

G.M.T.				Weather	Colour
1918	h m		m		
Aug. 27	8	R 3 a	5.92	clear	....
29	8 25	R 2 a	6.02	clear	....
Sept. 2	8 20	R 2.2 a	6.00	...	....
8	7 55	R 4 a	5.82	...	....
9	7 10	R 4 a	5.82	...	....
13	8 43	η 1 R 4 a	5.48	...	reddish
18	8 0	η 2 R	5.24	...	reddish
20	8 0	η 0.5 R	5.09	clear	....
21	6 45	η 1.2 R	5.16	...	reddish
25	7 20	η 4 R	5.44	clear	distinct reddish
27	9 4	η 3 R	5.34	clear	reddish
29	6 12	η 4 R	5.44	...	reddish
Oct. 2	6 21	η 4 R / R 3 a	5.68	...	reddish
6	8 22	R 4 a	5.82	...	reddish
8	5 39	η 3 R	5.34	...	reddish
9	6 20	η 5 R 4 a	5.68	...	orange-red
23	5 48	η 3 R	5.34	...	red
25	5 0	η 1.5 R	5.19	...	reddish
1918	h m		m		
Oct. 27	5 38	η 1 R	5.14	clear	red
28	5 37	η 2 R	5.24	...	orange
Nov. 9	4 33	η 2 R	5.24	...	reddish
11	5 6	η 2 R	5.24	...	faint reddish
12	5 24	η 4 R	5.44	...	faint rose
21	4 10	η 5 R	5.54	...	orange
22	4 11	η 4 R	5.44	...	orange
23	4 21	η 5 R	5.54	...	reddish
1919					
Mar. 20	15 30	η 2 R	5.24	...	reddish
24	15 15	η 5 R	5.54	clear	reddish
29	14 55	η 2 R	5.24	clear	distinct red
31	15 20	η 4 R	5.44	...	faint reddish
Apr. 1	15 24	η 2 R	5.24	...	red
3	15 0	η 3 R	5.34	...	red
13	15 10	η 4 R	5.44	...	red
19	14 15	a 1 R	6.32	clear	faint reddish
25	12 48	b 3 R	6.91	clear	reddish
May 5	12 8	b 5 R	7.06	clear	reddish
8	12 35	b 4 R	7.33	...	reddish
9	12 25	b 4 R	7.33	...	reddish
11	12 30	b 4 R	7.33	...	....
17	11 0	*	<7.00	...	....
20	10 45	*	<7.00	...	....
21	10 34	....	<7.00	.	....
June 5	10 28	R 2 a	6.02	...	red
7	11 10	R 1.5 a	6.07	...	red
9	11 12	......	<6.22	..	....
10	11 6	R 2.5 a	5.97	...	reddish
15	11 25	R 3 a	5.92	...	red
16	11 15	η 3 R 3 a	5.63	...	red
22	9 35	η 0 R	5.04	...	red
26	10 5	η 0.5 R	5.09	...	reddish
27	10 57	R 0.8 η	4.96	...	red
29	9 50	R 0.4 η	5.00	...	reddish

* R too faint to see.

1919		G.M.T. h m		m	Weather	Colour
July	1	10 10	R 0.4 η	5.00		reddish
	6	9 45	R 0.2 η	5.02	.	reddish
	7	10 20	R 1.5 η	4.89		red
	10	9 30	η 0.3 R	5.07		reddish
	12	9 30	R 0.4 η	5.00		reddish
	14	9 10	R 0.3 η	5.07		reddish
	15	10 35	η 0.4 R	5.08	clear	red
	17	10 10	η 0.6 R	5.10	..	reddish
	18	10 20	η 1 R	5.14	clear	reddish
	19	9 55	η 1.5 R	5.19	...	red
	21	10 15	η 0.8 R	5.12	clear	red
	22	10 0	η 1.3 R	5.17	...	red
	28	10 5	η 1.5 R	5.19	...	red
	29	10 10	η 1.5 R	5.19	...	rose
	30	10 8	η 1.5 R	5.19	...	red
Aug.	7	10 8	η 2.4 R	5.25	...	rose
	8	10 24	η 1.8 R	5.22	...	rose
	12	9 10	η 1.5 R	5.19	..	reddish
	14	9 10	η 1.5 R	5.19	...	reddish
	15	8 15	η 2 R	5.24	...	reddish
	17	8 50	η 2.5 R	5.29	clear	orange
	21	8 24	η 2 R	5.24	...	reddish
	23	8 27	η 2 R	5.24	...	orange
	25	8 4	η 2 R	5.24	..	orange
	31	7 51	η 1.5 R	5.19	clear	rose
Sept.	1	8 8	η 1.3 R	5.17	clear	reddish
	2	8 25	η 3 R	5.34	clear	reddish
	4	8 8	η 1.5 R	5.19	...	reddish
	5	7 35	η 2 R	5.24		reddish
	6	7 22	η 2.5 R	5.29	.	reddish
	7	7 40	η 3 R	5.34	..	reddish
	8	8 10	η 3 R	5.34	...	reddish
	10	7 38	η 4 R 1 a	5.63	...	reddish
	11	7 19	η 4 R 5 a	5.58	clear	red
	12	7 49	η 4 R	5.44	...	reddish
	15	6 48	η 3 R 4 a	5.58	clear	red
	16	7 3	η 4 R 3 a	5.68		red
	20	7 26	R 4 a	5.82	clear	reddish
	22	7 24	R 3.5 a	5.87	clear	reddish
	27	7 29	R 3 a	5.92		reddish
	29	6 0	R 2.5 a	5.97	clear	reddish
	30	6 0	R 2.5 a	5.97	clear	reddish
Oct.	4	6 22	R 3 a	5.92	..	orange
	7	6 1	R 2.5 a	5.97		reddish
	9	6 7	R 1.2 a	6.10	clear	reddish
	11	5 43	R 0.8 a	6.14	.	reddish
	14	6 14	R 1.5 a	6.07	clear	orange
	15	6 32	R 1.5 a	6.07	clear	reddish
	16	5 28	R 0.5 a	6.17	clear	reddish
	17	6 9	R 1.5 a	6.07	...	reddish
	22	5 18	R 1.5 a	6.07	clear	orange
	23	5 15	R 1.2 a	6.10	...	orange
	24	6 0	R 2 a	6.02	clear	reddish
	30	4 58	R 3.5 a	5.87	clear	reddish
Nov.	1	5 7	R 0 h	5.70	...	orange
	9	4 36	η 1 R	5.14	...	orange
	13	4 40	η 2 R	5.24	..	orange
	14	4 40	η 1.5 R	5.19	clear	reddish
	16	4 57	η 0.5 R	5.09	clear	red
	17	4 55	η 1 R	5.14	clear	reddish

With these magnitudes as basis I have constructed the following light curve.



This gives for *R Scuti*:

1919: Maximum: July 4d.6 4m.97 R.H. Ph.
Minimum: May 14d.0 7m.33 R.H. Ph.
Amplitude: 2m.36
Period evidently irregular.

Helsingør (Denmark),
26 March, 1920.

CONTENTS.

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THE PARALLAXES OF 261 STARS,

DETERMINED BY PHOTOGRAPHS WITH THE 26-INCH MC CORMICK REFRACTOR,

By S. A. MITCHELL

Assisted by C. P. OLIVIER, H. L. ALDEN and others.

The detailed results will appear as an *Adams Research Publication* from Columbia University, and as Volume III of the *Publications of the Leander McCormick Observatory*. The general method followed has been to obtain two photographic images on each plate, and to secure plates at five successive seasons. The scale of the photographs is 1 mm. = 20″.8.

For purposes of comparison, DR. W. S. ADAMS has kindly communicated in advance of publication the latest revised values of the spectroscopic parallaxes of Mt. Wilson.

In the following table is gathered the summary of measures of parallax and of proper-motion. 0″.005 has been subtracted from the values of the spectroscopic parallax. The proper-motion measured on the plates is the component in right ascension, or $\mu\alpha \cos\delta$, but referred to the particular set of comparison stars chosen. The corresponding value is taken from Boss or PORTER, those from PORTER being marked by an asterisk (*). The proper-motion from the photographs may differ from the catalogue value on account of errors in photograph and catalogue, from motions of the comparison stars, and from orbital motion in the case of binary stars. The average probable error of the proper-motion from photographs is 0″.01 per year. In the column "Measurer" is given the initials of the person responsible for the measurement of the plates. It has always been the policy of the McCormick Observatory to have each series of plates measured when possible by one person only. On account of changes in the personnel of the observatory staff, the measurement of a series of plates started by one person at times has been completed by another. In such cases the initial of the person is given who measured the majority of the plates.

M = S. A. MITCHELL; OL = C. P. OLIVIER; A = H. L. ALDEN; H = M. ALBERTA HAWES; D = MARGUARITE D. DARKOW; L = R. C. LAMB; B = G. B. BRIGGS; G = P. H. GRAHAM; F = JENNIE V. FRANCE.

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Parallax Spect. $-0''.005$	Proper-Motion Obs.	Proper-Motion Boss.	Meas.
		h m	° ′		″	″ ″	″	″	″	
1	*β Cassiop*	0 3	+58 35	2.42 F_5	0.54	+0.058 ± 0.011	+0.064	+0.524	+0.529	M
2	*Piazzi* 0h.130	0 32	−25 19	5.71 K_0	1.39	+ .086 ± .010	.061	+1.394	+1.384	A
3	*α Cassiop*	0 34	+55 59	2.2 K_0 2.8	0.060	+ .025 ± .005	.015	+0.041	+0.051	M
4	54 *Piscium*	0 34	+20 42	6.08 K_0	0.61	+ .101 ± .012	.100	−0.477	−0.463	D
5	*Lalande* 1198	0 39	+ 1 15	8.14 K_0	0.591	+ .039 ± .008	.045	−0.058	−0.063*	OL
6	*η Cassiop A*	0 43	+57 17	3.64 F_8	1.242	+ .180 ± .008	.161	+1.171	+1.127	M
7	*η Cassiop B*	0 43	+57 17	7.6 K_0	1.242	+ .178 ± .009	.161	+0.999	+1.127	M
8	*Lal.* 1799	0 57	+ 4 31	8.4 K_2	0.438	+ .022 ± .007	.058	+0.268	+0.353*	H
9	*ε Piscium*	0 57	+ 7 21	4.45 K_0	0.085	+ .022 ± .008	.009	−0.066	−0.080	A
10	*β Androm*.........	1 4	+35 5	2.37 Ma	0.216	+ .058 ± .008	.037	+0.248	+0.181	OL

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Parallax Spect. −0″.005	Proper-Motion Obs.	Proper-Motion Boss.	Meas.
		h m	° ′		″	″ ″	″	″	″	
11	*θ Cassiop.*	1 5	+54 37	4.52 A_5	0.230	+0.047 ± 0.013	....	+0.178	+0.229	A
12	*ω Androm.*	1 22	+44 53	4.96 F_5	0.356	+ .023 ± .010	+0.028	+0.372	+0.344	A
13	*η Piscium*	1 26	+14 49	3.72 G_5	0.031	+ .046 ± .010	.010	−0.019	+0.029	OL
14	*ν Androm.*	1 31	+40 54	4.18 G_0	0.418	+ .052 ± .008	.074	−0.190	−0.179	G
15	41 *H Androm.*	1 35	+42 6	5.10 F_8	0.82	+ .092 ± .013	.082	+0.854	+0.807	A
16	*τ Ceti*	1 39	−16 27	3.65 K_0	1.922	+ .312 ± .016	.311	−1.711	−1.717	M
17	*β Trianguli*	2 3	+34 30	3.08 A_5	0.159	+ .016 ± .008	....	+0.156	+0.152	B
18	*Lalande* 4141	2 9	+23 49	6.86 G_5	0.494	+ .034 ± .007	.031	+0.450	+0.452*	H
19	*δ Trianguli*	2 10	+33 46	5.07 G_0	1.15	+ .127 ± .010	.082	+1.183	+1.153	A
20	*Lalande* 4268	2 13	+ 1 17	5.82 F_8	0.527	+ .019 ± .005	.031	+0.407	+0.367	OL
21	*o Ceti*	2 14	− 3 25	2–9 Md	0.237	+ .061 ± .007	....	−0.001	−0.001	M
22	*Piazzi* 2h.123	2 30	+ 6 24	5.92 K_0	2.34	+ .137 ± .005	.133	+1.791	+1.802	OL
23	*γ Ceti*	2 38	+ 2 49	3.58 A_2	0.210	+ .037 ± .008	.033	−0.059	−0.147	M
24	*α Ceti*	2 57	+ 3 41	2.82 Ma	0.078	+ .017 ± .010	.021	+0.018	−0.013	A
25	*γ Persei*	2 57	+53 6	3.08 Gp	0.010	+ .002 ± .012	.018	−0.039	+0.004	A
26	*ρ Persei*	2 58	+38 27	3.4 4.2 Mc	0.173	+ .029 ± .012	.007	+0.105	+0.135	L
27	*α Persei*	3 17	+49 30	1.90 F_5	0.039	+ .013 ± .010	.018	+0.032	+0.027	A
28	*Lalande* 6320	3 20	− 5 42	8.1 K_0	0.816	+ .060 ± .010	.064	−0.266	−0.266*	A
29	*ε Eridani*	3 28	− 9 48	3.81 K_0	0.972	+ .302 ± .007	.276	−0.986	−0.971	M
30	10 *Tauri*	3 31	+ 0 5	4.40 G_5	0.536	+ .043 ± .006	.064	−0.260	−0.234	M
31	Σ 422	3 31	+ 0 15	6.12 G_0	0.151	+ .007 ± .007	.047	−0.077	−0.021	M
32	*W. B.* 3h.617	3 35	− 3 32	6.74 F_8	0.745	+ .021 ± .008	.017	+0.682	+0.713*	A
33	*ν Persei*	3 38	+42 15	3.93 F_5	0.009	+ .028 ± .012	.016	+0.029	+0.009	OL
34	*δ Eridani*	3 38	−10 6	3.72 K_0	0.749	+ .134 ± .011	.082	−0.083	−0.093	M
35	*Lalande* 6888	3 40	+41 9	8.2 G_5	1.38	+ .022 ± .009	.014	+0.629	+0.599	M
36	*Lalande* 6889	3 40	+41 9	8.8 G_5	1.38	+ .028 ± .009	.033	+0.631	+0.599	M
37	*τ*[6] *Eridani*	3 42	−23 32	4.33 F_8	0.548	+ .068 ± .010	.043	−0.162	−0.163	M
38	32 *Eridani Bt.*	3 49	− 3 15	4.95 Gp	0.035	+ .008 ± .010	.006	+0.031	+0.034	F
39	32 *Eridani Ft.*	3 49	− 3 15	6.33 A	0.035	− .009 ± .009	....	+0.032	......	F
40	*γ Eridani*	3 53	−13 47	3.19 K_5	0.130	+ .014 ± .012	.024	+0.045	+0.067	A
41	43 *Tauri*	4 3	+19 20	5.67 G_5	0.114	+ .019 ± .012	.008	+0.076	+0.075	A
42	*o*[2] 40 *Erid. A*	4 10	− 7 48	4.48 G_5	4.085	+ .194 ± .009	.211	−2.224	−2.220	M
43	*o*[2] 40 *Erid. BC*	4 10	− 7 48	9.7 A	4.085	+ .214 ± .008	....	−1.767	.....	M
44	*ξ Eridani*	4 18	− 3 58	5.23 A_2	0.072	+ .010 ± .009	....	−0.083	−0.050	A
45	*α Tauri*	4 30	+16 19	1.06 K_5	0.201	+ .035 ± .008	.093	+0.072	+0.069	M
46	Boss 1128	4 42	+63 20	5.81 Ma	0.113	− .003 ± .011	.004	+0.027	+0.056	H
47	*π*[3] *Orionis*	4 44	+ 6 47	3.31 F	0.471	+ .151 ± .009	.113	+0.497	+0.471	M
48	*A.G. Leip.* 1819	4 44	+ 6 48	7.05 A_2	....	− .002 ± .015	....	−0.026	......	M
49	*W. B.* 4h.1189	4 56	− 5 52	6.50 K_0	1.247	+ .124 ± .007	.113	+0.562	+0.550*	OL
50	*ε Leporis*	5 1	−22 30	3.29 K_5	0.072	+ .017 ± .011	.025	+0.026	+0.026	B

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Parallax Spect −0″.005	Proper-Motion Obs.	Proper-Motion Boss	Meas.
		h m	° ′		″	″ ″	″	″	″	
51	*λ Aurigæ*	5 12	+40 0	4.85 G_0	0.846	+0.061 ± 0.009	+0.074	+0.534	+0.529	F
52	*β Leporis*	5 24	−20 50	2.96 G_0	0.094	− .001 ± .005	.013	+0.007	+0.006	OL
53	*W. B.* 5h.592	5 26	− 3 41	8.8 K_2	2.222	+ .164 ± .009	.177	+0.811	+0.741*	D
54	*α Leporis* . . .	5 28	−17 53	2.69 F_0	0.003	+ .009 ± .008	.050	+0.023	+0.001	M
55	*Groomb.* 990	5 30	+51 22	7.9 K_0	0.563	+ .024 ± .007	.039	−0.567	−0.552*	F
56	*γ Leporis Bt.*	5 40	−22 28	3.80 F_5	0.468	+ .148 ± .009	.095	−0.277	−0.296	M
57	*γ Leporis Ft.* . . .	5 40	−22 28	6.11 G_5	0.461	+ .140 ± .007	.110	−0.271	−0.278	M
58	*δ Leporis*	5 47	−20 53	3.90 K_0	0.696	+ .019 ± .010	.028	+0.239	+0.241	H
59	*χ Orionis* . . .	5 48	+20 15	4.62 F_5	0.208	+ .105 ± .006	.100	−0.145	−0.186	A
60	*δ Auriga*	5 51	+54 17	3.88 K_5	0.153	− .004 ± .006	.018	+0.078	+0.086	A
61	*η Leporis* . . .	5 51	−14 11	3.77 F_0	0.138	+ .031 ± .010	.053	−0.012	−0.041	OL
62	*β Aurigæ* . . .	5 52	+44 56	2.07 A_p	0.047	+ .026 ± .009	. . . .	−0.076	−0.047	A
63	*η Geminorum*	6 8	+22 32	3.2–4.2 Ma	0.065	− .001 ± .010	.009	−0.045	−0.062	OL
64	*2 Lyncis*	6 10	+59 2	4.12 A_0	0.022	+ .021 ± .011	. . .	+0.005	−0.005	OL
65	Boss 1599 . . .	6 15	− 2 54	5.18 Ma	0.009	− .009 ± .010	.004	−0.012	−0.009	OL
66	*μ Geminorum* .	6 16	+22 33	3.19 Ma	0.128	+ .011 ± .007	.028	+0.043	+0.061	OL
67	*β Canis Maj.* .	6 18	−17 54	1.99 B_1	0.002	+ .007 ± .010	. .	+0.024	−0.006	M
68	47 *Aurigæ*	6 22	+46 45	6.01 K_0	0.007	+ .012 ± .010	.003	+0.006	+0.005	D
69	*ε Geminorum*	6 37	+25 13	3.18 G_5	0.020	.000 ± .009	.007	+0.011	0.000	OL
70	*ξ Geminorum*	6 39	+13 0	3.40 F_5	0.231	+ .037 ± .007	.047	−0.118	−0.114	OL
71	97 *Monocerotis* . .	6 45	− 0 25	5.83 F_2	0.175	+ .026 ± .009	.043	+0.091	+0.008	A
72	*Lalande* 13427 . . .	6 54	+48 31	8.2 K_0	0.697	+ .007 ± .007	.039	+0.556	+0.540*	H
73	Boss 1846	7 5	+51 35	5.69 Ma	0.018	− .011 ± .012	.003	+0.019	+0.018	H
74	*Lalande* 14146 . .	7 11	−12 53	7.72 G_5	0.513	+ .031 ± .010	.016	−0.488	−0.501*	A
75	*δ Geminorum* . . .	7 14	+22 9	3.51 F_0	0.023	+ .060 ± .006	.028	−0.041	−0.016	OL
76	*ι Geminorum* . . .	7 19	+28 0	3.89 K_0	0.145	+ .008 ± .006	.016	−0.085	−0.082	A
77	*ρ Geminorum*	7 22	+31 59	4.18 F_1	0.236	+ .052 ± .007	.024	+0.173	+0.149	M
78	*α¹ Geminorum*	7 28	+32 6	2.85 A_0	0.204	+ .086 ± .007	. . . .	−0.119	−0.172	A
79	*α² Geminorum*	7 28	+32 6	1.99 A_0	0.204	+ .067 ± .010	. . . .	−0.182	. . . . . .	A
80	*α Canis Min.*	7 34	+ 5 29	0.48 F_5	1.25	+ .309 ± .007	.353	−0.690	−0.666	M
81	*γ Monocerotis*	7 36	− 9 19	4.07 K_0	0.079	.000 ± .011	.014	−0.076	−0.076	A
82	*κ Geminorum*	7 38	+24 38	3.68 G_5	0.066	+ .014 ± .008	.023	−0.019	−0.022	L
83	9 *Puppis*	7 47	−13 38	5.34 G_0	0.344	+ .036 ± .008	.078	+0.035	−0.060	M
84	*Lal.* 15290	7 47	+30 54	8.2 G_0	1.962	+ .033 ± .007	.015	+0.701	+0.732*	M
85	*ρ Puppis*	8 3	−24 0	2.88 F_5	0.100	+ .026 ± .008	.024	−0.060	−0.089	OL
86	*Lal.* 15950	8 5	+32 46	6.95 G_0	0.82	+ .040 ± .010	.053	−0.456	−0.454	A
87	*β Cancri*	8 11	+ 9 29	3.76 K_2	0.075	− .002 ± .010	.016	−0.079	−0.052	OL
88	*Lal.* 16304	8 13	−12 17	6.04 G_5	1.03	+ .060 ± .007	.105	+0.285	+0.279	OL
89	*Lal.* 17046	8 34	+11 53	7.9 G_5	0.531	+ .026 ± .009	.043	−0.113	−0.104*	A
90	*δ Cancri*	8 39	+18 31	4.17 K_0	0.240	+ .038 ± .009	.016	+0.009	−0.017	OL

No.	Star	R. A. 1900	Decl. 1900	Mag and Spect.	μ	Parallax McCormick	Spect. −0".005	Proper-Motion Obs.	Boss.	Meas.
		h m	° ′		"	" "	"	"	"	
91	*ι Cancri Bt.*	8 40	+29 7	4.20 G_7	0.054	+0.026 ± 0.006	+0.003	−0.022	−0.020	M
92	*ι Cancri Ft.*	8 40	+29 7	6.61 A_5	0.054	+ .031 ± .006	....	−0.037	......	M
93	*ε Hydræ* ...	8 41	+ 6 47	3.48 F_8	0.196	+ .004 ± .010	.047	−0.177	−0.189	A
94	53 *Cancri* ..	8 46	+28 38	6.31 Ma	0.022	− .005 ± .012	.000	+0.002	−0.016	OL
95	55 *Cancri* ..	8 46	+28 42	6.06 K_0	0.55	+ .076 ± .011	.078	−0.523	−0.481	OL
96	*ζ Hydræ* ...	8 50	+ 6 19	3.30 K_0	0.103	.000 ± .010	.009	−0.105	−0.103	A
97	38 *Lyncis* ..	9 12	+37 13	3.82 A_2	0.136	+ .039 ± .010	....	+0.016	−0.026	D
98	*θ Urs. Maj.*	9 26	+52 7	2.36 F_8p	1.092	+ .032 ± .008	.082	−0.952	−0.945	M
99	*λ Leonis* ...	9 26	+23 24	4.48 K_5	0.056	+ .034 ± .008	.011	−0.009	−0.023	A
100	*ο Leonis* ...	9 35	+10 21	3.76 F_5p	0.150	+ .029 ± .012	...	−0.113	−0.145	A
101	35 *Leonis* ..	10 11	+24 0	5.91 G_0	0.209	+ .005 ± .008	.021	−0.181	−0.208	M
102	*ζ Leonis* ...	10 11	+23 54	3.65 F_0	0.027	+ .005 ± .007	.012	+0.013	+0.022	M
103	*γ¹ Leonis* ...	10 14	+20 20	2.61 K_0	0.339	− .002 ± .009	.043	+0.376	+0.302	M
104	*γ² Leonis* ..	10 14	+20 20	3.80 K_0	0.353	− .021 ± .015	.011	+0.385	+0.302	M
105	40 *Leonis* .	10 14	+19 58	4.97 F_5	0.329	+ .047 ± .009	.039	−0.218	−0.234	OL
106	*β Leo Minor*	10 22	+37 13	4.41 K_1	0.164	+ .008 ± .009	.018	−0.128	−0.122	A
107	46 *Leo Minor* ..	10 47	+34 45	3.92 K_0	0.304	+ .047 ± .009	.028	+0.076	+0.091	M
108	*Lal.* 21258 ..	11 0	+44 2	9.2 K_5	4.519	+ .177 ± .012	.177	−4.398	−4.334*	M
109	*χ Leonis* ..	11 0	+ 7 53	4.66 F	0.348	+ .007 ± .010	.011	−0.302	−0.345	OL
110	*Lal.* 21565 ..	11 13	− 4 31	7.34 K_0	0.806	+ .043 ± .012	.055	+0.818	+0.793	D
111	*λ Draconis* .	11 25	+69 52	4.06 Ma	0.042	+ .013 ± .005	.010	−0.048	−0.034	OL
112	93 *Leonis* ..	11 42	+20 46	4.54 F_8	0.155	+ .024 ± .009	.047	−0.123	−0.156	G
113	*β Virginis* ...	11 45	+ 2 20	3.80 F_8	0.793	+ .096 ± .008	.082	+0.751	+0.743	M
114	*Groomb.* 1830 .	11 47	+38 26	6.46 G_5	7.037	+ .106 ± .008	.074	+4.053	+4.004	M
115	*γ Urs. Maj.* ..	11 48	+54 15	2.54 A_0	0.093	− .002 ± .007	....	+0.131	+0.093	A
116	Boss 3137 ...	11 55	− 9 52	5.63 G_5	0.491	+ .087 ± .012	.064	+0.054	+0.109	D
117	*ε Corvi*	12 5	−22 3	3.21 K	0.064	+ .021 ± .009	.024	−0.023	−0.063	F
118	*β Canum Ven.* .	12 29	+41 54	4.32 G_0	0.78	+ .102 ± .009	.102	−0.671	−0.701	H
119	*θ Virginis*	13 4	− 5 0	4.44 A	0.058	+ .006 ± .006	....	−0.029	−0.039	M
120	*β Comæ*	13 7	+28 23	4.32 G_0	1.184	+ .140 ± .013	.115	−0.798	+0.797	A
121	61 *Virginis* .	13 13	−17 45	4.80 K	1.51	+ .130 ± .011	.100	−1.011	−1.077	L
122	*γ Hydræ*	13 13	−22 39	3.33 G_5	0.084	+ .007 ± .010	.017	+0.176	+0.067	OL
123	*ζ¹ Urs. Maj.* .	13 19	+55 26	2.40 Ap	0.129	+ .046 ± .010	....	+0.108	+0.126	M
124	*ζ² Urs. Maj.* ...	13 19	+55 26	3.96 A_2	0.137	+ .017 ± .009	.018	+0.103	+0.132	M
125	*g Urs. Maj.*	13 21	+55 30	4.02 A_5	0.124	+ .029 ± .009	....	+0.123	+0.122	M
126	70 *Virginis*	13 24	+14 19	5.16 G_5	0.634	+ .045 ± .008	.050	−0.250	−0.243	A
127	*ο Virginis*	13 29	+ 4 10	4.93 Ap	0.052	+ .023 ± .010	....	+0.052	+0.042	A
128	*Lal.* 25224	13 34	+11 15	5.54 A	0.112	+ .021 ± .006	.006	−0.054	−0.111	L
129	*Lal.* 25372	13 40	+15 26	8.7 K	2.298	+ .224 ± .016	.204	+1.728	+1.780*	OL
130	*μ Virginis*	14 38	− 5 13	3.95 F_5	0.339	+ .043 ± .010	.043	+0.124	+0.106	A

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Parallax Spect −0″.005	Proper-Motion Obs.	Proper-Motion Bos.	Meas.
		h m	° ′		″	″ ″	″	″	″	
131	*ξ Boötis*	14 46	+19 31	4.64 G_0	0.168	+0.200 ± 0.012	+0.153	+0.150	+0.150	OL
132	*β* 31 ..	14 48	+19 8	8.0 K_3	0.185	+ .002 ± .010	.017	+0.007	−0.022[a]	OL
133	*Lal.* 27173 *Bt.*	14 51	−20 57	5.76 Kp	2.039	+ .172 ± .010	.161	+0.994	+1.034	M
134	*Lal.* 27173 *Ft.*	14 51	−20 57	8.7 Ma	2.07	+ .206 ± .005	.204	+0.812	+0.919	M
135	*β Boötis*	14 58	+40 47	3.63 G_0	0.063	+ .037 ± .015	.008	−0.032	−0.016	A
136	*μ Boötis A* ..	15 20	+37 43	4.17 F	0.169	+ .049 ± .008	.030	−0.112	−0.119	D
137	*μ Boötis BC* .	15 20	+37 43	6.66 K	0.169	+ .031 ± .009	.027	−0.146	−0.115	D
138	*α Cor. Bor.*..	15 30	+27 3	2.31 A	0.157	+ .056 ± .010	....	+0.111	+0.120	OL
139	*α Serpentis*...	15 39	+ 6 44	2.75 K_0	0.139	+ .038 ± .008	.024	+0.129	+0.135	M
140	*β Serpentis*..	15 11	+15 44	3.74 A_2	0.091	+ .029 ± .008	....	+0.045	+0.071	M
141	*γ Serpentis*...	15 51	+15 59	3.86 F_5	1.32	+ .098 ± .008	.110	+0.278	+0.302	A
142	*ρ Cor. Bor.*..	15 57	+33 36	5.43 F	0.780	+ .018 ± .012	.039	−0.187	−0.213	H
143	*ξ Scorp. AB* ..	15 59	−11 5	4.7 F_5	0.071	+ .018 ± .010	.033	−0.018	−0.062	M
144	*ξ Scorp. C* ...	15 59	−11 5	7.2	0.080	+ .046 ± .012	.035	−0.064	−0.075	M
145	*ν Scorp. AB* ..	16 6	−19 12	4.29 B_3	0.034	+ .010 ± .010	....	−0.077	−0.011	M
146	*ν Scorp. CD* ..	16 6	−19 12	6.49 A	0.014	+ .042 ± .015	....	−0.057	−0.004	M
147	49 *Serp. A* ...	16 8	+13 47	7.1 K_0	0.459	+ .075 ± .010	.047	+0.213	+0.169	M
148	49 *Serp. B* ..	16 8	+13 47	7.3 K	0.459	+ .073 ± .011	..	+0.205	......	M
149	*δ Ophiuchi* ..	16 9	− 3 26	3.03 Ma	0.157	+ .040 ± .010	.024	−0.020	−0.048	D
150	*ε Ophiuchi* ..	16 13	− 4 27	3.34 K	0.085	+ .046 ± .012	.017	+0.102	+0.079	H
151	*η Draconis*...	16 22	+61 44	2.89 G_5	0.062	+ .002 ± .010	.031	−0.022	−0.018	A
152	*λ Ophiuchi*...	16 25	+ 2 12	3.58 A	0.097	+ .009 ± .008	....	−0.047	−0.048	A
153	*η Herculis*...	16 39	+39 6	3.61 K	0.101	+ .047 ± .008	.024	+0.056	+0.034	OL
154	*α Herculis*...	17 10	+14 30	3.48 Mb	0.030	+ .006 ± .008	.002	−0.028	−0.012	F
155	*δ Herculis* ..	17 10	+24 57	3.16 A	0.165	+ .016 ± .009	...	−0.022	−0.024	M
156	*β Draconis*..	17 28	+52 22	2.99 G	0.016	− .015 ± .007	.009	−0.024	−0.011	A
157	*β Ophiuchi* ...	17 38	+ 4 36	2.94 K	0.157	+ .021 ± .010	.030	−0.029	−0.041	M
158	*μ Herculis*....	17 42	+27 46	3.48 G_5	0.817	+ .108 ± .009	.105	−0.258	−0.324	M
159	*ν Ophiuchi*..	17 53	− 9 45	3.50 K	0.119	+ .024 ± .011	.013	+0.011	−0.012	A
160	*γ Draconis*..	17 54	+51 30	2.42 K_5	0.027	.000 ± .006	.039	+0.028	−0.008	OL
161	BARNARD's Star .	17 54	+ 4 25	9.7 Mb	10.3	+ .539 ± .008	....	−0.715	......	M
162	70 *Ophiuchi A*	18 0	+ 2 30	4.07 K_0	1.131	+ .173 ± .007	.195	+0.137	+0.253	M
163	70 *Ophiuchi B*	18 0	+ 2 30	6.1 K_6	1.131	+ .184 ± .009	.153	+0.385	+0.253	L
164	99 *Herculis*.... ..	18 3	+30 32	5.21 F	0.113	+ .044 ± .010	.061	−0.082	−0.095	M
165	*Schjellerup* 16	18 14	− 5 0	7.8	....	− .004 ± .006	....	+0.094	......	H
166	*χ Draconis*.......	18 22	+72 11	3.69 F_8	0.638	+ .090 ± .011	.115	+0.435	+0.495	OL
167	110 *Herculis*......	18 41	+20 27	4.26 F_5	0.345	+ .060 ± .009	.058	+0.002	−0.021	A
168	*γ Lyræ*	18 55	+32 33	3.30 A	0.007	+ .007 ± .009	....	−0.003	−0.002	A
169	*ζ Sagittarii*.......	18 56	−30 1	2.71 A_2	0.022	+ .018 ± .008	....	+0.066	+0.022	OL
170	*ζ Aquilæ*.........	19 1	+13 43	3.02 A	0.102	+ .027 ± .010	..	−0.023	−0.009	OL

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect	"	Parallax McCormick	Parallax Spect. −0".005	Proper-Motion Obs	Proper-Motion Boss.	Meas.
		h m			"	" "	"	"	"	
171	*π Sagittarii*	19 3	−21 10	3.02 F_2	0.040	+0.012±0.012	+0.003	−0.032	−0.005	OL
172	*Aquil. 59 Bt.*	19 8	+16 41	6.44 A	0.03	− .004± .008	...	+0.016	....	M
173	*Aquil. 59 Ft.*	19 8	+16 41	7.9 G_0	0.243	+ .016± .011	.021	+0.054	+0.138*	M
174	Σ 2481 *A* ...	19 8	+38 37	8.0 G_5	0.267	+ .046± .011	.025	−0.196	−0.226*	M
175	Σ 2481 *BC* = *Sc*2	19 8	+38 37	8.0 G_5	0.267	+ .018± .010	.025	−0.304	−0.226*	M
176	*Cygni 6 A* ...	19 10	+49 40	6.62 K	0.63	+ .051± .006	.061	−0.227	−0.188	M
177	*Cygni 6 B* .	19 10	+49 40	6.84 K	0.654	+ .036± .007	.050	−0.281	−0.173	M
178	*ρ Sagittarii* .	19 15	−18 2	3.95 F	0.031	+ .044± .010	.030	−0.007	−0.024	B
179	*δ Aquilæ* ..	19 20	+ 2 54	3.44 F	0.264	+ .041± .010	.043	+0.270	+0.253	OL
180	31 *b Aquilæ*	19 20	+11 43	5.23 G_5	0.96	+ .074± .010	.091	+0.729	+0.725	B
181	*β¹ Cygni* ..	19 26	+27 45	3.24 Kp	0.014	− .006± .010	.024	−0.011	−0.011	OL
182	*β² Cygni* ..	19 26	+27 45	5.36 B_0	0.009	.000± .006	..	−0.011	−0.003	OL
183	*Lal.* 37120 .	19 29	+32 58	6.61 G_0	0.517	+ .042± .007	.031	−0.473	−0.472	B
184	*σ Draconis* .	19 32	+69 27	4.78 K	1.82	+ .181± .007	.149	+0.558	+0.557	A
185	*θ Cygni* ...	19 33	+49 59	4.64 F_5	0.249	+ .080± .011	.053	+0.055	−0.028	OL
186	*α Sagittæ* ..	19 35	+17 47	4.37 G	0.036	− .009± .008	.003	+0.017	+0.016	G
187	16¹ *Cygni* ..	19 39	+50 17	6.26 F	0.217	+ .036± .009	.053	−0.143	−0.155	M
188	16² *Cygni* .	19 39	+50 17	6.37 F_5	0.220	+ .030± .011	.039	−0.123	−0.132	M
189	*γ Aquilæ*	19 41	+10 22	2.80 K_2	0.014	+ .029± .011	.027	+0.001	+0.013	A
190	Σ 2580 *A*	19 42	+33 29	5.03 F_5	0.452	+ .057± .009	.033	−0.007	+0.010	M
191	Σ 2580 *B* ..	19 42	+33 29	8.1	0.452	+ .042± .008	.043	+0.007	......	M
192	Σ 2576 *AB*.	19 42	+33 23	8.5 K_0	0.433	+ .036± .008	.061	−0.034	+0.016*	M
193	*α Aquilæ* ...	19 45	+ 8 36	0.89 A_5	0.64	+ .218± .007	....	+0.546	+0.536	M
194	*η Aquilæ* ..	19 47	+ 0 45	3.7 4.4 G_0	0.012	− .001± .009	− .002	+0.018	+0.008	A
195	*ξ Aquilæ*	19 49	+ 8 12	4.86 G_5	0.126	+ .034± .009	+ .010	+0.095	+0.095	OL
196	*β Aquilæ* ..	19 50	+ 6 9	3.90 K_0	0.484	+ .066± .011	.095	+0.018	+0.035	M
197	*Lal.* 38287 ..	19 58	+15 20	7.19 G_5	0.608	+ .078± .006	.043	−0.162	−0.171*	OL
198	*Lal.* 38383	19 59	+23 5	7.20 K_0	1.369	+ .075± .009	.071	−1.017	−1.030*	A
199	*B.D.* 36°.3883.	20 4	+36 17	7.44 K_0	....	− .009± .010	.002	+0.002	......	OL
200	*Lal.* 38683 ...	20 6	+15 53	7.3 G_5	0.55	+ .054± .013	....	−0.390	......	H
201	*o¹ Cygni* ...	20 10	+46 30	4.96 A_2	0.017	+ .022± .009	....	−0.020	+0.015	A
202	*o² Cygni* ..	20 10	+46 26	3.95 Kp	0.002	− .002± .013	.011	+0.001	+0.002	A
203	*α¹ Capricorni*	20 12	−12 49	4.55 G	0.016	− .017± .009	− .002	+0.025	+0.015	OL
204	*α² Capricorni*	20 12	−12 51	3.77 K	0.058	− .017± .013	+ .021	+0.032	+0.058	OL
205	*β¹ Capricorni*	20 15	−15 6	3.25 Gp	0.035	+ .002± .008	.021	−0.007	+0.035	M
206	*β² Capricorni* ...	20 15	−15 6	6.16 A	0.042	.000± .010	....	+0.006	+0.042	M
207	*γ Cygni*	20 18	+39 56	2.32 F_8p	0.003	− .003± .010	.004	+0.004	+0.001	H
208	*ρ Capricorni*	20 23	−18 8	4.96 F	0.026	+ .019± .013	.005	+0.001	−0.014	M
209	Boss 5247	20 23	−18 12	7.1	0.136	+ .011± .010	....	+0.057	+0.040	M
210	41 *Cygni*	20 25	+30 2	4.09 F_5	0.010	− .023± .006	.023	+0.016	+0.009	D

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	μ	Parallax McCormick	Spect − 0″.005	Proper-Motion Obs.	Proper-Motion Boss	Meas.
		h m	° ′		″	″ ″	″	″	″	
211	*β Delphini*	20 33	+14 14	3.72 F_5	0.113	+0.008 ± 0.008	+0.041	−0.118	+0.108	OL
212	*52 Cygni*	20 41	+30 21	4.31 G_5	0.028	+ .009 ± .009	.019	−0.028	−0.016	L
213	*γ Delphini Bt.*	20 42	+15 46	4.49 G_5	0.207	+ .038 ± .009	.016	−0.108	−0.033	M
214	*γ Delphini Ft.*	20 42	+15 46	5.47 G_5	0.195	+ .046 ± .008	.027	−0.078	−0.020	M
215	*ε Cygni*	20 42	+33 35	2.64 K_0	0.483	+ .039 ± .008	.039	+0.356	+0.360	M
216	*η Cephei*	20 43	+61 27	3.59 K_0	0.826	+ .064 ± .013	.078	+0.104	+0.097	B
217	*μ Aquarii*	20 47	− 9 21	4.80 F	0.052	+ .005 ± .008	....	+0.058	+0.037	OL
218	*ε Equul. AB*	20 54	+ 3 55	5.29 F_5	0.191	+ .021 ± .010	.016	−0.125	−0.126	M
219	*ε Equul. C*	20 54	+ 3 55	7.1	0.191	+ .002 ± .011	.010	−0.135	−0.126	M
220	*W.B.* 20^h.1454	20 59	+ 2 36	8.0 F_8	0.485	+ .005 ± .009	.010	−0.289	−0.297*	OL
221	61¹ *Cygni*	21 2	+38 15	5.57 K	5.271	+ .306 ± .005	.317	+4.161	+4.148	M
222	61² *Cygni*	21 2	+38 15	6.28 K_5	5.157	+ .308 ± .006	.283	+4.161	+1.134	M
223	*ζ Cygni*	21 8	+29 49	3.40 K_0	0.059	+ .028 ± .010	.008	−0.002	−0.003	A
224	*τ Cygni*	21 10	+37 37	3.82 F_0	0.454	+ .046 ± .007	.037	+0.159	+0.158	F
225	*δ Equulei*	21 10	+ 9 36	4.61 F_5	0.306	+ .041 ± .007	.055	+0.029	+0.041	OL
226	*α Cephei*	21 16	+62 9	2.60 A_5	0.160	+ .091 ± .008	....	+0.154	+0.152	OL
227	*β Aquarii*	21 26	− 6 0	3.07 G	0.016	− .001 ± .012	.004	+0.005	+0.014	B
228	*γ Capricorni*	21 34	−17 6	3.80 Fp	0.188	+ .013 ± .009	.030	+0.169	+0.187	OL
229	*76 Cygni*	21 37	+40 21	6.05 A	0.052	+ .005 ± .012	....	−0.030	−0.010	A
230	*ε Pegasi*	21 39	+ 9 25	2.54 K_0	0.025	+ .017 ± .008	.023	+0.022	+0.025	OL
231	*μ Cygni*	21 39	+28 17	4.73 F_5	0.371	− .041 ± .010	.053	+0.330	+0.283	M
232	*κ Pegasi*	21 40	+25 11	4.27 F_5	0.033	+ .016 ± .008	.031	+0.010	+0.032	M
233	*δ Capricorni*	21 41	−16 34	2.98 A_5	0.392	+ .110 ± .012	....	+0.262	+0.258	H
234	*22 Pegasi*	22 0	+ 4 34	4.90 Kp	0.138	+ .012 ± .008	+ .007	+0.090	+0.103	D
235	*α Aquarii*	22 0	− 0 48	3.19 G_0	0.015	+ .005 ± .010	− .001	+0.002	+0.014	M
236	*ι Pegasi*	22 2	+24 51	3.96 F_5	0.299	+ .091 ± .008	+ .082	+0.273	+0.299	OL
237	*ζ Cephei*	22 7	+57 42	3.62 K	0.013	+ .019 ± .010	.019	+0.011	+0.011	OL
238	*ε Cephei*	22 11	+56 32	4.22 A_5	0.153	+ .053 ± .008	....	+0.462	+0.450	H
239	*Lal.* 43492	22 12	+12 24	6.94 G_0	0.853	+ .052 ± .007	.053	+0.839	+0.847*	A
240	*ζ¹ Aquarii*	22 23	− 0 31	4.42 F_5	0.173	+ .034 ± .013	.023	+0.156	+0.172	A
241	*ζ² Aquarii*	22 23	− 0 31	4.59 F_5	0.212	+ .029 ± .010	.024	+0.166	+0.207	A
242	*Krueger 60 A*	22 24	+57 11	9.3 Mb	0.94	+ .267 ± .011	.185	−0.671	−0.797*	M
243	*Krueger 60 B*	22 24	+57 11	10.8	0.94	+ .265 ± .014	....	−0.946	−0.797*	M
244	*Krueger 60 C*	22 24	+57 11	9.2	....	+ .001 ± .010	....	+0.006	......	M
245	*η Pegasi*	22 38	+29 42	3.10 G_0	0.036	− .008 ± .010	.017	−0.058	+0.010	OL
246	*ξ Pegasi*	22 41	+11 39	4.31 F_5	0.54	+ .046 ± .011	.074	+0.205	+0.227	L
247	*μ Pegasi*	22 45	+24 4	3.67 K_0	0.154	− .006 ± .012	.025	+0.167	+0.147	A
248	*ι Cephei*	22 46	+65 40	3.68 K_0	0.139	+ .048 ± .008	.025	−0.091	−0.068	A
249	*Lal.* 45028	22 56	− 4 23	7.60 K_0	0.478	+ .053 ± .011	.041	+0.405	+0.418*	OL
250	*β Pegasi*	22 58	+27 32	2.61 Mb	0.234	− .005 ± .006	.025	+0.197	+0.192	OL

No.	Star	R. A. 1900	Decl. 1900	Mag. and Spect.	″	Parallax McCormick	Parallax Spect. −0″.005	Proper-Motion Obs.	Proper-Motion Bos.	Meas.
		h m	° ′		″	″ ″	″	″	″	
251	*7 Androm.*	23 8	+48 51	4.62 F	0.137	+0.033 ± 0.010	+0.030	+0.088	+0.095	OL
252	*W. B.* 23h 175	23 11	−14 21	8.3 F_8	1.305	+ .028 ± .007	....	−0.534	−0.490*	M
253	*Lal.* 45585	23 12	− 2 4	8.5	0.265	+ .025 ± .013	..	+0.235	+0.249	OL
254	*γ Piscium*	23 12	+ 2 44	3.85 K_0	0.753	+ .044 ± .010	.017	+0.748	+0.750	OL
255	*Lal.* 45638	23 14	+ 4 52	8.6 G_5	0.492	+ .005 ± .007	.039	+0.487	+0.479*	M
256	*υ Pegasi*	23 20	+22 51	4.57 G_0	0.191	+ .007 ± .009	.016	+0.194	+0.189	L
257	*ι Piscium*	23 34	+ 5 5	4.28 F_5	0.574	+ .067 ± .007	.078	+0.361	+0.370	A
258	Boss 6129	23 47	+74 59	6.55 K	0.332	+ .088 ± .008	.100	+0.315	+0.329	D
259	*ρ Cassiopeiæ*	23 49	+56 57	4.85 F_8p	0.007	+ .041 ± .010	− .003	−0.028	−0.005	A
260	Boss 6142	23 50	+56 61	6.05 Bp	0.006	+ .025 ± .010	....	−0.008	−0.005	A
261	*ω Piscium*	23 54	+ 6 19	4.03 F_5	0.185	+ .018 ± .009	+ .041	+0.135	+0.149	G

Leander McCormick Observatory, University of Virginia, September, 1920.

ON THE COMPARATIVE DISTANCES OF CERTAIN GLOBULAR CLUSTERS AND THE STAR CLOUDS OF THE MILKY WAY,

By E. E. BARNARD.

Just as the great star clouds of the Milky Way act as a background against which non-luminous masses may be seen in dark relief, they must also act as a screen and thus hide any object that is behind them. This gives us a means of inferring the relative distances, etc., of many of the great globular clusters. The rich regions of *Sagittarius* and *Aquila*, in which some of the finest globular clusters occur, are specially remarkable for their density. That these clusters are nearer than the great star clouds is evident, for they would not be seen through the star clouds if beyond them. Several facts are suggested by this. These clusters are relatively small bodies compared with the great star clouds of the Milky Way. Their distances are less than the stars which make up the clouds of the Milky Way. From this it also seems certain that the individual stars composing them are not comparable with the ordinary stars of the Milky Way: for the latter must be much more luminous bodies and presumably larger. Of the clusters that thus appear to be nearer to us than the star clouds of the Milky Way a few only will be selected.

		h m s	° ′
N.G.C. 6266 = *M* 62	1900.0	α 16 54 51	δ − 29 57.6
N.G.C. 6273 = *M* 19	1900.0	α 16 56 27	δ − 26 6.9
N.G.C. 6293	1900.0	α 17 3 56	δ − 26 26.5
N.G.C. 6304	1900.0	α 17 8 12	δ − 29 20.4
N.G.C. 6333 = *M* 9	1900.0	α 17 13 20	δ − 18 24.7
N.G.C. 6528	1900.0	α 17 58 23	δ − 30 3.7
N.G.C. 6656 = *M* 22	1900.0	α 18 30 19	δ − 23 59.3
N.G.C. 6712	1900.0	α 18 47 38	δ − 8 49.7

These are all seen on a bright stellar background. *N.G.C.* 6712 is seen against the splendid cloud in *Scutum* and must be nearer to us than the great star cloud itself. There are also other clusters to which these remarks apply. Of the other clusters that are not globular, *M* 11 is a fine example of this relative nearness.

Yerkes Observatory, Williams Bay, Wisconsin. 1920, September 1.

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OBSERVATIONS OF 060547, *SS AURIGÆ*, AND MAGNITUDES OF FAINT COMPARISON STARS,

By H. L. ALDEN and S. A. MITCHELL.

The observation of long-period variable stars with the twenty-six inch telescope of the McCormick Observatory was begun in 1903 and continued regularly until the departure in 1912 of PROFESSOR STONE, the former Director of the Observatory. About four thousand observations had been made during that time on more than one hundred and twenty-five variables. After an interruption of three years the observation of these stars was resumed by MR. ALDEN in the summer of 1915. Since that time a number of the members of the Observatory staff have taken part in the observations and six thousand additional estimates of brightness have been made. The observing program has been considerably modified and extended so as to include most of the long-period variables available at this latitute whose magnitude at minimum is less than thirteen, besides stars of special interest.

The large aperture of the McCormick telescope should make these observations form a very valuable contribution to our knowledge of the variations of these stars when at or near minimum. The present method of coöperation with the Harvard College Observatory enables us to concentrate our efforts on the variables which are faint, thus supplementing the work of observers with telescopes of moderate aperture.

060547, *SS Aurigæ*, is a star of special interest since it belongs to the same class as *SS Cygni* and *U Geminorum*. At minimum it is fainter than the fifteenth magnitude, the rise to maximum being often very rapid. The star was placed on the program in December 1916. To date two hundred and twenty-six observations have been made showing seventeen maxima. This paper contains the results of these observations together with data regarding the magnitudes of the faint comparison stars.

COMPARISON STARS

A sequence of comparison stars for this variable was selected at the Harvard College Observatory and data regarding them are contained in *Harvard Circular* 138. As the visual magnitudes are there given only to 13.26, it has been necessary to extend the scale to fainter stars in order to reduce the observations made at this Observatory. Since the magnitudes of faint comparison stars are now being determined in a number of variable star fields at the McCormick Observatory, the general method of procedure will be described first. It is as follows:

1. The intervals in brightness between the successive stars of the sequence are estimated in grades on at least four nights, beginning usually with stars of magnitude eleven or twelve.

2. The brightness of at least five stars distributed throughout the fainter portion of the sequence, together with five brighter stars whose magnitudes have been photometrically determined at the Harvard College Observatory, are measured on four nights with the wedge photometer. The measures are reduced using the Harvard photometric magnitudes to determine the zero-point.

3. The grade estimates are reduced graphically to the photometric scale.

4. HAGEN's grade estimates taken from the *Atlas Stellarum Variabilium* and the Harvard grade estimates taken from the *Annals* are also reduced graphically to the McCormick photometric scale when they extend to stars fainter than those which have been photometrically determined at Harvard.

5. The mean of the Harvard, HAGEN and McCormick visual, and the Harvard and McCormick photometric magnitudes, or such of these quantities as are common to a particular star, is then adopted as the magnitude of that comparison star.

In the case of *SS Aurigæ* this method has been somewhat modified. Sufficient sequences were contained in the observations themselves so that very good values of the grade intervals can be determined. This star is not included in HAGEN'S Atlas. The photometric measures were made without reference to stars which have Harvard photometric magnitudes but they were adjusted to the photometric zero-point. The visual magnitudes of the stars *r*, *s*, and *t* were used as given in *Harvard Circular* 138 since they were already in good accord with the McCormick photometric magnitudes.

Table I contains the data for the comparison stars. Column one gives the Harvard designation; columns two and three, the right ascension and declination for 1900; column four, the Harvard photometric and column five the Harvard visual magnitudes. These data are taken from Table 1 of *Harvard Circular* 138, the visual magnitude being obtained by adding the quantity in the "*Diff.*" column to the photometric magnitude for each star.

Column six gives the McCormick photometric magnitudes derived from measures made on four nights by each of us. Many of the magnitudes are the mean of fourteen separate but not entirely independent determinations, the average number being eleven. The average deviations from the mean for stars brighter than magnitude thirteen is 0.105 mag. and for those fainter than magnitude thirteen 0.174 mag., the mean of all being 0.133 mag. The average probable error of a magnitude computed from the residuals is ±0.035. This does not include the errors of scale. Column seven contains the mean of the grade estimates, the average number of estimates for each interval being thirteen. Column eight gives the McCormick visual magnitude corresponding to the grade estimate for each star. Column nine contains the adopted magnitudes of the comparison stars, each value being the mean of the quantities in columns four, five, six and eight. These values are used for the reduction of the observations.

TABLE I

COMPARISON STARS

Designation	R. A. 1900	Decl. 1900	Harvard Ptm.	Harvard Vis.	McCormick Ptm.	McCormick Grades	McCormick Vis.	Adopted Magnitude
	6^h	+47°						
	m s							
f	6 12.0	35.2	10.50	10.54	10.52	0.0	10.51	10.52
g	6 8.2	42.3	10.78	10.74	...	2.8	10.78	10.77
h	5 26.1	33.0	10.62	10.92	..	...	....	10.77
k	5 48.9	47.7	10.98	10.60	10.89	3.3	10.84	10.82
l	6 30.9	49.2	10.87	11.16	10.93	5.3	11.04	11.00
m	5 30.2	37.4	11.22	11.08	11.21	7.7	11.27	11.20
n	7 4.9	49.8	11.45	11.36	11.62	9.3	11.43	11.46
o	5 21.0	39.8	11.43	11.80	11.32	9.9	11.49	11.51
p	5 48.1	32.1	11.80	11.80	11.60	14.4	11.94	11.78
q	6 9.3	46.2	12.42	12.42	12.50	20.2	12.52	12.46
r	5 14.9	48.1	....	12.64	12.05	19.2	12.43	12.37
s	5 18.3	41.2	....	12.98	13.05	24.7	13.03	13.02
t	5 27.0	44.1	...	13.26	13.11	26.9	13.26	13.21
u	5 35.7	44.1	..	..	13.79	31.1	13.76	13.78
v	5 39.0	46.2		...	13.94	32.8	13.93	13.94
x	5 54.6	45.7	.	....	14.64	36.9	14.44	14.54
y	5 58.1	45.4		...	....	40.4	14.83	14.83
z	5 55.0	45.3		....	...	43.4	15.18	15.18
a	5 46.5	45.2	..	....	....	48.7	15.8	15.8

Discordant values were obtained from the visual estimates for two of these stars, namely *o* and *r*. In the first case the star is almost certainly variable with a range of about half a magnitude. It has been

omitted from the reductions whenever the variable has been compared with at least two other stars. Otherwise the value given above has been used. Star r is certainly brighter than q and a better value of its magnitude would probably be obtained by omitting the Harvard visual estimate. The value in the table was employed in the reductions since the magnitude of the variable would not be changed appreciably by a slight change in the magnitude of this star.

Subtracting the adopted *visual* magnitudes of the faint stars from the Harvard *photographic* magnitudes given in the above-mentioned *Circular*, the color indices will be as given in Table II. The first column gives the Harvard designation; the second, the Harvard photographic magnitude; the third, the adopted visual magnitude and the fourth column, the color index. In the fifth column is the spectral type corresponding to the color index, assuming that the relation between these quantities as given in *Harvard Annals 80*, 151 is applicable to fainter stars. This assumption takes for granted that both systems of magnitudes are on the International scale and that the distribution of energy throughout the spectra of faint stars is the same as for brighter stars of the same spectral type. As the result has no direct bearing on the object of this paper, the validity of these assumptions need not be discussed.

TABLE II

Color Indices of Faint Stars

Star	Photographic Mag.	Visual Mag.	Color Index	Spectral Type
t	13.66	13.21	+0.45	F_6
u	13.91	13.78	+0.13	A_5
w	14.11	13.94	+0.17	A_6
x	15.08	14.54	+0.54	F_9
y	15.43	14.83	+0.60	G_1
z	15.78	15.18	+0.60	G_1
a	16.09	15.80	+0.29	F_1

A good check on the photometric scale is furnished by the limiting magnitude of the McCormick telescope. The faintest star visible should be about the sixteenth magnitude. The adopted magnitude of the star a is 15.8. This star has been observed only under excellent conditions of seeing and transparency, and while its magnitude has been extrapolated beyond the limit of the photometric measures, the value adopted seems to check the accuracy of the scale and zero-point used.

The Observations

Table III contains all the observations of the variable to date. Column one gives the calendar date; column two, the Julian Day; column three, the observation; column four, the resulting magnitude and column five the observer. The Julian Day is given to two decimal places because of the rapid change in the brightness of the variable in some portions of its light curve. Only portions of the sequences actually observed have been given here and only the portion published has been used in deriving the magnitude of the variable. The observations have been reduced by Mr. Alden. The designations of the observers are as follows:— M = S. A. Mitchell, A = H. L. Alden, Ol = C. P. Olivier, L = R. C. Lamb, and Br = G. B. Briggs.

TABLE III

Observations

Date		Julian Day 2,421,000+	Observation	Mag.	Obsr.
1916					
Dec.	17	215.70	$v = m$	11.20	M
	30	228.66	$x\ 5\ y\ 2\ z\ 3\ v$	15.25	A
1917					
Jan.	11	240.60	$v < x$	<14.54	L
	25	254.65	$y\ 2\ v\ 1\ z$	15.06	L
Feb.	16	276.69	$g\ 2\ k\ 1\ v\ 1\ l$	10.93	Ol
	24	284.71	$x\ 2\ y\ 4\ z\ 1\ v$	15.28	A
Mar.	5	293.69	invisible $v < u < w$	<13.94	M
	15	303.70	invisible $v < z$	<15.18	A
	17	305.60	$v < z$	<15.18	L
	18	306.56	invisible $v < z$	<15.18	M
	20	308.62	gl'n ps'd $z\ 3\ v$	15.5	M
	22	310.66	$w\ 1\ x\ 4\ y\ 4\ z\ 1\ v$	15.36	A
	24	312.62	$w\ 2\ x\ 3\ y\ 3\ z\ 3\ v$	15.63	M
	25	313.62	$w\ 3\ x\ 3\ y\ 3\ z\ 2\ v$	15.46	M
	27	315.56	$w\ 3\ x\ 3\ y\ 1\ v\ 2\ z$	14.95	M
	28	316.65	$x\ 3\ v = y$	14.83	Ol
	29	317.59	$q\ 2\ r\ 2\ v\ 2\ s\ 3\ t$	12.74	M
		.59	$q\ 2\ r\ 2\ v\ 2\ s\ 3\ t$	12.74	L
		.77	$v = q$	12.16	M
	30	318.51	$g\ 2\ k\ 5\ m\ 2\ v\ 1\ o$	11.42	Ol
		.51	$n = v\ 3\ p$		
		.60	$m\ 3\ o = v\ 5\ p,\ n\ 1\ v$	11.40	Ol
	31	319.55	$l\ 3\ m\ 3\ o\ 2\ v\ 1\ p\ 6\ q$	11.61	M
		.55	$n\ 1\ v$		
		.55	$m\ 3\ v\ 1\ o,\ l\ 4\ n\ 1\ v$	11.45	A
		.55	$m\ 2\ v\ 2\ o$	11.36	Ol
		.55	$m\ 2\ v\ 2\ o$	11.36	L
Apr.	2	321.53	$p\ 4\ v\ 2\ q$	12.23	M
		.53	$p\ 3\ q = v\ 2\ r$	12.26	Ol
		.53	$o\ 6\ v\ 1\ q$	12.32	A

Date	Julian Day 2,421,000+	Observation	Mag.	Obsr.
1917				
Apr. 3	322.55	*q* 2 *r* 2 *v* 3 *s*	12.77	A
	.55	*r* 2 *v* 2 *s*	12.70	L
	.55	*r* 2 *v* 2 *s*	12.70	M
5	324.57	*s* 3 *t* 4 *u* 1 *v* 1 *w*	13.83	A
	.57	*t* 3 *v* 1 *w* 1 *u*	13.64	L
7	326.63	$v = x$	14.54	A
16	335.57	$v = z$	15.18	L
May 11	360.56	$v < x$	<14.54	A
12	361.56	$v < x$	<14.54	M
14	363.56	glimpsed *y* 5 *v*	15.20	M
15	364.56	glimpsed *y* 5 *v*	15.20	M
19	368.56	invisible $v < w$	<13.94	M
21	370.56	invisible $v < t$	<13.21	M
23	372.59	invisible $v < y$	<14.83	Ol
24	373.58	invisible $v < x$	<14.54	M
25	374.58	*s* 1 *v* 2 *t*	13.15	M
29	378.59	*o* 3 *v* 5 *q*	11.87	A
Sept. 12	484.93	Invisible $v < x$	<14.54	A
17	489.47	$v = x$	14.54	M
	.47	$v = x$	14.54	A
	.64	*w* 10 *x* 3 *v* 2 *y* 2 *z* 5 *a*	14.80	Ol
19	491.74	*x* 2 *v*	14.70	M
21	493.81	Invisible $v < x$	<14.54	A
26	498.73	glimpsed $v < x$	14.60	M
29	501.77	Invisible $v < u$	<13.78	M
Oct. 1	503.74	Invisible $v < w$	<13.94	A
2	504.75	Invisible $v < x$	<14.54	A
5	507.75	Invisible $v < x$	<14.54	A
6	508.76	*x* 4 *v*	14.90	M
7	509.75	*x* 2 *v*	14.70	M
9	511.75	$v = x$	14.54	A
15	517.73	$v = y$	14.83	M
20	522.79	$v = x$	14.54	M
27	529.77	*u* 2 *v* 1 *w*	13.89	A
28	530.62	*r* = *v* 2 *q*	12.37	M
	.62	*r* = *v* 2 *q*	12.37	A
30	532.65	*g* = *k* 1 *v* 1 *l*	10.90	M
	.74	$g = v = k$	10.80	M
31	533.63	*g* = *k* 2 *l* 1 *v* 1 *m* 2 *o* = *n*	11.15	M
	.80	*k* 2 *l* 1 *v* 1 *m* 3 *o*	11.10	A
	.94	*k* 2 *l* 2 *m* 1 *v* 2 *o*	11.30	A
Nov. 1	534.57	*l* 2 *m* 3 *v* 1 *o*	11.43	A
	.75	*l* 2 *m* 4 *v* = *o* 4 *p*	11.48	A
2	535.67	*m* 2 *o* 3 *v* 2 *p* 5 *r*	11.66	A
	.67	*o* 4 *v* 6 *r*	11.85	Br
	.95	*m* 2 *o* 5 *v* 6 *q*	11.88	M
3	536.72	*m* 2 *o* 4 *p* 1 *v* 4 *r* 4 *q*	12.05	A
4	537.60	*l* 3 *m* 4 *p* 1 *v* 1 *r* 3 *q* 5 *s*	11.97	M
	.60	*m* 4 *p* 2 *v* = *r* 3 *s*	12.16	A
	.80	*o* 8 *v* 1 *q*, *r* 1 *v* 2 *q*	12.38	Ol
1917				
Nov. 5	538.66	*r* 3 *q* 1 *v* 4 *s*	12.65	M
	.66	*o* 8 *r* 2 *v* 1 *q* 5 *s*	12.44	A
6	539.71	*w* 1 *v* 1 *u*	13.86	Ol
7	540.71	*u* 2 *v* = *w*	13.95	M
	.71	*s* 1 *t* 5 *u* 2 *v* = *w*	13.98	A
8	541.71	*w* 3 *v* 2 *x*	14.30	A
	.71	*w* 3 *v* 2 *x*	14.30	M
10	543.75	*w* 5 *v* 1 *x*	14.44	M
Dec. 10	573.58	*v* 1 *x*	14.40	M
	.58	*v* 1 *x*	14.40	A
12	575.63	$v = x$	14.54	A
	.63	$v = x$	14.54	M
29	592.53	$v < w$	<14.00	M
1918				
Jan. 3	597.66	$v = y$	14.83	M
7	601.63	*f* 1 *v* 2 *g*	10.60	A
8	602.47	$v = g = k$	10.80	M
	.47	*v* 3 *g*	10.60	Ol
9	603.47	$v = g = k$	10.80	M
	.66	*k* 1 *v* 1 *l*	10.91	M
10	604.63	*v* 1 *g*	10.70	A
12	606.48	*k* 1 *v* 1 *l*	10.91	M
	.83	$v = l$	11.00	M
13	607.46	$v = l$	11.00	M
14	608.54	$v = l$	11.00	M
15	609.49	*k* 4 *v*, *l* 2 *v* 2 *n*	11.23	M
17	611.52	*v* 3 *q*	12.20	M
	.52	*k* 7 *m* 6 *r* 3 *v* 3 *q* 5 *s*	12.27	A
18	612.84	$v = s$	13.02	A
20	614.71	$v = x$	14.54	M
Feb. 10	635.72	$v = z$	15.18	M
17	642.71	$v < x$	<14.54	M
21	646.65	Invisible $v < w$	<13.94	A
28	653.63	Invisible $v < w$	<13.94	A
Mar. 7	660.67	*u* 2 *w* 5 *x* 1 *v* 2 *y*	14.62	A
10	663.53	*x* 2 *v*	14.70	M
11	664.65	*w* 5 *x* 3 *y* = *v* 3 *z*	14.84	A
18	671.58	$v = x$	14.54	A
19	672.63	*y* 4 *z* 2 *v* 5 *a*	15.36	Ol
25	678.58	*x* 1 *v*	14.60	A
28	681.54	$v = m$	11.20	A
30	683.64	*g* 3 *v* 1 *m* 2 *o*	11.09	M
31	684.62	*m* 2 *o* 5 *v* 3 *r* 2 *q*	11.97	M
Apr. 2	686.53	$v = q$	12.46	M
	.53	*q* 2 *v* 1 *r*	12.40	Ol
4	688.62	*s* = *t* 5 *u* 2 *w* 2 *v* 1 *x*	14.39	A
Sept. 14	851.66	$v = x$	14.54	M
21	858.89	$v < x$	<14.54	M
22	859.85	$v < x$	<14.54	M
27	864.63	$v < x$	<14.54	M
28	865.69	*x* 1 *v*	14.60	M

Date	Julian Day 2,421,000+	Observation	Mag.	Obsr.
1918				
Oct. 1	868.71	$r = x$	14.54	M
2	869.68	$r = x$	14.54	M
4	871.70	$r < 13.5$	<13.50	M
5	872.82	x 1 r	14.60	M
7	874.58	$r < x$	<14.54	M
10	877.61	x 2 r	14.70	M
12	879.81	$r = x$	14.54	M
15	882.64	$r = g = k$	10.80	M
16	883.65	$g = k$ 2 r	11.00	M
21	888.67	s 3 r	13.30	M
22	889.59	t 4 r	13.60	M
Nov. 27	925.65	m 3 n 1 r	11.55	M
30	928.76	t 1 r	13.30	M
Dec. 2	930.60	r 2 x	14.30	M
27	955.65	x 3 r	14.80	M
29	957.64	x 2 r	14.70	M
30	958.68	x 3 r	14.80	M
1919				
Jan. 4	963.63	g 4 $r = m$ 2 o	11.23	M
5	964.52	$r = m$	11.20	M
6	965.63	m 2 $o = n$ 2 r 2 p	11.60	M
8	967.59	r 2 r 1 q	12.43	M
9	968.56	q 2 r 3 s	12.68	M
10	969.60	$r = t$	13.21	M
11	970.76	u 1 r	13.90	M
12	971.63	w 2 r	14.10	M
26	985.70	$r = x$	14.54	M
28	987.62	x 2 r	14.70	M
Feb. 1	991.68	x 1 r	14.60	M
4	994.62	m 2 o 2 r 3 p	11.53	M
5	995.52	m 2 o 3 r 1 p	11.68	M
6	996.50	p 3 r 3 q	12.12	M
	2,422,000+			
10	000.50	r 1 x	14.40	M
26	016.71	x 4 $r = y$	14.85	M
Mar. 12	030.67	m 2 o 3 r 1 p	11.68	M
23	041.64	$r = x$	14.54	M
30	048.62	x 2 r	14.70	M
Apr. 2	051.63	r 3 x	14.20	M
7	056.59	invisible $r < t$	<13.21	OL
14	063.58	invisible $r < q$	<12.46	OL
17	066.58	$r = x$	14.54	OL
19	068.61	$r = y$	14.83	OL
24	073.62	w 1 x 1 r	14.5±	OL
		(estimated brighter than mag. 14.0)		
26	075.60	$r =$ or $< x$	14.6	M
27	076.58	$r = y$	14.83	M
May 2	081.62	x 1 r 3 y	14.61	M
3	082.60	m 2 r 2 o	11.36	OL
4	083.60	$g = k$ 2 r 2 m 2 o	11.00	M
Aug. 27	198.90	invisible $r < w$	<13.94	OL
Sept. 20	222.86	x 3 r	14.80	M

Date	Julian Day 2,422,000+	Observation	Mag.	Obsr.
1919				
Sept. 23	225.83	k 2 $r = l = o$ 2 m	10.99	M
		(*o unquestionably brighter than m)		
24	226.71	f 2 r 1 $g = k$ 4 m 2 o	10.70	A
25	227.74	l 2 $r = m = o$	11.20	M
26	228.73	m 3 $r = o$ 1 p	11.64	OL
27	229.70	m 1 o 2 r 3 p	11.49	M
28	230.72	k 4 $o = m$ 6 $p = r$ 4 r 3 q	11.82	A
29	231.69	p 4 r 4 q	12.12	M
Oct. 3	235.67	invisible $r < x$	<14.54	A
Nov. 3	266.71	invisible $r < x$	<14.54	A
13	276.70	z 1 r	15.30	A
20	283.72	k 3 r 1 m 1 o	11.10	A
21	284.75	k 2 r	11.00	M
22	285.70	$r = g = k$	10.80	M
24	287.70	k 2 r	11.00	M
26	289.71	k 2 r 3 $m = o$	10.97	M
30	293.60	p 4 r 2 q	12.23	M
Dec. 1	294.98	invisible $r < t$	<13.21	A
4	297.69	invisible $r < w$	<13.94	A
22	315.73	$r = y$	14.83	M
1920				
Jan. 1	325.52	invisible $r < t$	<13.21	A
2	326.60	invisible $r < w$	<13.94	A
5	329.60	invisible $r < w$	<13.94	A
12	336.70	$r = z$	15.18	A
	.70	$r = z$	15.18	M
13	337.70	$r = z$	15.18	A
14	338.68	$r = y$	14.83	M
17	341.49	$r = y$	14.83	A
19	343.65	$r = y$	14.83	A
28	352.58	$r = z$	15.18	A
31	355.60	invisible $r < x$	<14.54	A
Feb. 2	357.60	invisible $r <$ mag. 14.0	<14.00	M
7	362.60	$r = z$	15.18	A
10	365.55	$r = x$	14.54	M
15	370.64	$r = q$	12.46	M
16	371.66	m 3 r 3 o	11.26	OL
17	372.52	f 1 r 1 k 1 g	10.63	A
19	374.64	m 4 r 2 o, l 5 r	11.40	OL
26	381.63	$r = y$	14.83	A
Mar. 13	397.58	$r = y$	14.83	M
Apr. 11	426.64	glimpsed x 3 r	14.80	M
14	429.65	z 2 r 2 a	15.50	A
22	437.66	k 3 r 1 m	11.10	M
23	438.62	k 3 r 1 m	11.10	M
24	439.60	k 2 r 2 m	11.01	A
28	443.58	l 1 r 1 m 3 o	11.10	OL
29	444.54	m 2 r 1 o	11.40	A
May 1	446.60	r 2 q	12.30	M
2	447.62	q 4 r 2 s	12.83	M
3	448.61	$r = t$	13.21	M

Leander McCormick Observatory, University of Virginia,
August, 1920.

PARALLAXES OF 41 STARS,

DERIVED FROM PLATES TAKEN WITH THE 40 INCH TELESCOPE OF THE YERKES OBSERVATORY,

By OLIVER J. LEE AND GEORGE VAN BIESBROECK.

The following stellar parallaxes were obtained in the year ending July 1, 1920. Only one essential change in the manner of proceeding has been made. The bracket support for the rotating sector was rebuilt in the summer of 1919 so that the disks are now located less than 2 cm. from the plate instead of 14 cm. as heretofore. This eliminates the danger of distortion of the cone of light of the parallax star by the axis and edge of the sector.

The average probable error for this list of parallaxes is ±0″.0090, the average number of plates for a field is 14.5 and the average number of comparison stars for a field is 4.3. The seventh column gives the annual proper-motion in right ascension obtained in the respective solutions.

The details of the work will appear later in the *Publications of the Yerkes Observatory*.

Including this list the number of published parallaxes from Yerkes Observatory is 225.

No.	Star	α (1900)	δ (1900)	*B. D.* No.	Magn.	Spect.	Proper-Motion	Rel. Parallax	p. e.	No. of Plates	No. of Comp. Stars	Mean Mag. of Comp. Stars
		h m	° ′	°			s	″	″			
1	*B.G.C.* 12755	0 1	+57 53	+57 2865	6.9	*G5*	+0.033	+0.008	+0.015	12	5	9.5
2	α *Cassiopeiæ*	0 35	+55 59	+55 139	2.1 to 2.6	*K0*	+0.005	− .004	.006	15	4	10
3	*B.D.* +63° 137	1 0	+63 24	+63 137	8.6	*K6*	+ .228	+ .068	.011	13	4	10
4	ε *Cassiopeiæ*	1 47	+63 11	+62 320	3.4	*B5*	+ .001	− .006	.003	14	4	10.5
5	P.M. Star near *W And.*	2 12	+43 49	......	12.4	...	+ .044	+ .043	.015	11	4	13
6	*B.D.* +45° 992	4 44	+45 41	+45 992	7.1	*F9*	+ .034	+ .035	.007	10	3	11
7	*Capella*	5 9	+45 54	+45 1077	0.2	*G0*	+ .007	+ .078	.007	23	4	10
8	Comp. to *Capella*	5 10	+45 44	....	10	...	+ .006	+ .070	.006	23	4	10
	Mean	.....	....	....	..	...	......	+ .073	.004	..	.	...
9	*B.D.* +17° 1320	6 31	+17 38	+17 1320	9.5	...	− .051	+ .085	.008	13	5	9.5
10	γ *Geminorum*	6 32	+16 29	+16 1223	1.9	*A*	+ .006	+ .044	.010	13	3	10
11	*Sirius*	6 41	−16 35	−16 1591	−1.6	*A*	− .036	+ .367	.010	15	5	8.7
12	97 *Monocerotis*	6 46	− 0 25	− 0 1462	5.8	*A*	+ .002	+ .043	.006	20	4	10.5
13	13 σ_2 *Urs. Maj.*	9 2	+67 32	+67 577	4.9	*F8*	+ .003	+ .037	.007	13	3	10
14	12 α_1 *Can. Ven.*	12 51	+38 51	+39 2580	5.4	...	− .019	− .011	.008	14	3	11
15	12 α_2 *Can. Ven.*	12 51	+38 51		2.9	*Ap*	− .019	+ .039	.010	14	3	11
	Mean	...	......	.....	....	...	− .019	+ .015	.006	..	...	...
16	*W.B.* 13h 241	13 15	+35 39	+35 2436	9.0	....	+ .040	+ .045	.010	13	5	10.5
17	Oxf. ph. 25° 86067	13 55	+25 44	....	10.4	....	+ .002	+ .006	.010	12	4	10.5
18	*Arcturus*	14 11	+19 42	+19 2777	0.2	*K*	− .075	+ .095	.006	16	4	10
19	44 *i Bootis B*	15 1	+48 3	+48 2259	...	....	− .040	+ .077	.008	20	3	10.5
20	44 *i Bootis A*	15 1	+48 3		4.9	*G*	− .044	+ .097	.008	19	3	10.5
	Mean	....	....	....	....	...	− .012	+ .087	.006	..	.	...
21	*W.B.* 15h 1323	15 55	+28 1	+28 2503	8.0	*G8*	− .057	+ .048	.009	14	4	11
22	μ_1 *Draconis*	17 3	+54 36	+54 1857	5.8	*F5*	− .007	+ .039	.010	16	3	11
23	μ_2 *Draconis*	17 3	+54 36		5.8	*F5*	− .002	+ .049	.007	16	3	11
	Mean	.	.	....	..	..	.	+ .040	.006	..	...	...
24	55 α *Ophiuchi*	17 30	12 38	+12 3252	2.1	*A5*	+ .016	+ .055	.008	11	5	10.5
25	*B.D.* +40° 3374	18 21	+40 38	+40 3371	9.2	...	+ .017	+ .025	.007	11	5	10
26	*B.D.* +20° 3876	18 34	+20 33	+20 3876	9	...	− .001	+ .042	.007	13	5	9.5
27	β *Lyræ*	18 46	+33 15	+33 3223	3.4 to 4.1	*B2p*	+ .001	− .011	.010	16	4	10.5
28	*B. G. C.* 9114 *A*	19 8	+38 37	+38 3466	8	....	− .020	+ .009	.009	14	6	10
29	*B. G. C.* 9114 *BC*	19 8	+38 37		9	....	− .018	+ .018	.008	14	6	10
	Mean	...	....	....	....	....	− .019	+ .013	.006	..	.	...

No.	Star	α 1900	δ 1900	B. D. No.	Magn	Spect	Proper Motion	Rel. Parallax	p. e.	No. of Plates	No. of Comp. Stars	Mean Mag. of Comp. Stars
		h m	° ′				s	″	″			
30	*Cygni* 6 pr.	19 9	+49 10	+49 2959	6.8	K	−0.019	+0.05[illegible]	±0.008	12	6	10.5
31	*Cygni* 6 fol.	19 9	+49 10		6.6		− .022	+ .023	.007	12	6	10.5
	Mean	...	...	...	...	...	...	+ .037	.005	..	..	...
32	ζ *Sagittæ*	19 45	+18 53	+18 4251	5.0	A	+ .002	+ .015	.010	14	5	10.5
33	α *Aquilæ*	19 46	+ 8 36	+ 8 4236	0.9	A5	+ .034	.184	.010	20	4	9
34	*B. G. C.* 10289	20 27	−10 12	−10 5423	5.8	G	+ .019	+ .031	.008	17	5	10.5
35	ε *Cygni*	20 42	+33 36	+33 4018	2.6	K	+ .030	+ .002	.011	13	4	10.5
36	66 υ *Cygni*	21 14	+34 29	+34 4371	4.4	B3p	+ .001	+ .013	.003	12	4	10.5
37	ξ *Cephei* pr.	22 1	+64 8	+63 1802	6.5	....	+ .033	+ .016	.015	11	6	10.5
38	ξ *Cephei* fol.	22 1	+64 8		4.7	A8	+ .030	+ .047	.009	11	6	10.5
	Mean	.....	.....	.....	...	.....	.....	+ .039	.008	..	.	...
39	Mun. I 31343	22 34	+ 2 0	+ 1 4637	9.4	...	− .001	+ .014	.007	14	5	10.5
40	β *Pegasi*	22 59	+27 32	+27 4480	2.2 to 2.7	Mb	+ .013	+ .044	.008	15	4	10
41	*B. G. C.* 12608	23 48	+74 59	+74 1047	6.6	K	+ .074	+ .062	.008	13	4	10

ELEMENTS OF THE ASTEROID OF COMAS SOLA.

BY BANCROFT WALKER SITTERLY.

The accompanying elements were computed from five observations of Comas Sola's asteroid made by MR. E. C. BOWER with the Washington twenty-six inch telescope during the first three months of 1920. The method used was that of the variation of geocentric distances, using as the first approximation the orbit of M. BLONDEL of Marseilles, which was published in *Popular Astronomy* for April 1920. The three trial orbits used in this method were computed to satisfy exactly the first and last Washington observations, the geocentric distances for the first orbit being obtained directly from the BLONDEL elements; the first of these distances was increased in computing the second orbit, and the second distance diminished in computing the third orbit. It appeared, however, that the deviations of the Washington observations from the BLONDEL elements were so great that the second-order terms of the expressions for these differences, which by this method are assumed negligible, had in fact a considerable effect, and none of the three orbits found gave small enough residuals to warrant the least-square solution for true geocentric distances; so a fourth orbit was computed, varying both distances considerably. This orbit came close enough to the observations to be used, with the first and third trial orbits, as material for the least-squares correction, and final values for the geocentric distances were thereby obtained, with which the fifth and last orbit was computed. Residuals from this orbit give $\pm 1''.14$ as probable error of one coördinate of an observation, so the fit is considered satisfactory.

TABLE I. THE OBSERVATIONS, BY MR. E. C. BOWER

No.	1920	app. R. A.	app. decl.
		h m s	° ′ ″
1	Jan. 28.592604 G. M. T.	7 48 7.63	20 51 20.5
2	Feb. 13.621724	7 32 18.45	19 7 15.2
3	Feb. 26.606064	7 24 59.23	17 44 57.2
4	Mar. 8.598669	7 23 9.71	16 39 25.3
5	Mar. 18.562385	7 21 15.67	15 13 15.3

TABLE II. THE ELEMENTS. REFERRED TO THE MEAN EQUINOX OF 1920.0

	M. Blondel's elements, used as the first approximation	Final elements
log a	0.431295	0.431286
ϕ	4° 16′ 26″.6	4° 12′ 41″.7
e	0.074527	0.082140
i	21° 23′ 37″.5	21° 6′ 33″.5
☊	299° 41′ 58″.2	299° 43′ 29″.2
ω	188° 21′ 51″.5	198° 56′ 52″.8
μ	799″.952	799″.976
M	353° 37′ 17″.3	344° 44′ 40″.8
E	1920 Jan. 30.5 G.M.T.	1920 Jan. 30.5 G.M.T.

It will be noted that though the first and last observations were to be exactly fitted in computing the orbits, small residuals are given for them in the tables. This is because, in order to save time, only six place logarithm tables were used in the calculation, instead

TABLE III. THE RESIDUALS

No.	O – C Blondel's Orbit		O – C Final Orbit	
	s	"	s	"
1	−0.10	+12.4	−0.07	−0.2
2	−0.90	+3.8	+0.15	−0.9
3	−1.13	−18.3	+0.05	−2.1
4	+0.55	−38.7	+0.06	−0.3
5	+3.38	−60.6	−0.03	+0.1

of seven, giving results good individually only to the nearest second of arc. This was considered, however, to be within the limit of error of the observations, and hence permissible.

The only considerable difference between M. BLONDEL's elements and those here communicated is in the longitude of perihelion, which is altered by ten degrees. The eccentricity is increased slightly, and the inclination a trifle lessened. The other differences are almost inappreciable.

TABLE IV. DIFFERENCES BETWEEN THE FINAL ELEMENTS AND THOSE OF M. BLONDEL

	Final – Blondel
$\log a$	−0.000009
e	+0.007613
i	− 0° 17′ 4″.0
Ω	+ 0° 1′ 31″.0
ω	+10° 35′ 1″.3
μ	+0″.024
M	−8° 52′ 36″.5

I should like finally to express my appreciation to PROFESSOR RUSSELL, the director of the Princeton observatory, for supervising and correcting this work, which was assigned as an exercise in the determination of orbits.

Princeton University Observatory,
June, 1920.

POSITION OF *NOVA CYGNI*, NO. 3,

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Six observations on the 9-inch transit circle of the U. S. Naval Observatory give the following position of the *Nova*; (Epoch 1920.67);

α (1920.0)	prec.	δ (1920.0)	prec.
$19^h\ 56^m\ 24^s.65$	$+1^s.5005\ -0^s.0034$	+53° 24′ 1″.0	+9″.749 +0″.187

SEARCH EPHEMERIS OF ENCKE'S COMET,

BY F. E. SEAGRAVE.

1920 G. Midnight	α	δ	Log r	Log Δ	1920 G. Midnight	α	δ	Log r	Log Δ
	h m s	° ′ ″				h m s	° ′ ″		
Nov. 1	22 46 38	−0 46 25	0.49256	0.38946	17	22 40 40	−1 38 5	0.47816	0.41276
5	22 44 32	−1 2 41	0.48910	0.39496	21	22 40 10	−1 45 16	0.47434	0.41889
9	22 42 50	−1 16 48	0.48554	0.40071	25	22 40 4	−1 50 5	0.47040	0.42499
13	22 41 33	−1 28 35	0.48190	0.40666	29	22 40 19	−1 52 38	0.46638	0.43107

The comet is due to reach perihelion July 12, 1921.

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COMPARISONS OF PHOTOGRAPHIC STELLAR PARALLAX

By ALBERT S. FLINT.

PREFATORY NOTE

[This article was completed at the date printed at its close but laid aside for possible inclusion of additional observed parallaxes to be published from time to time. It is now offered as a contribution to the history of parallax investigation. The wording of the text has been amended in some places, but the numbers and the course of the discussion remain the same.]

In the *Astronomical Journal*, No. 696, the present writer incidentally expressed his conviction that the list of twenty-nine photographic parallaxes there considered were subject to an appreciable systematic error. This conclusion rested upon four partly independent series of comparisons, whose results were presented graphically in Figs. 10 and 11. The number of parallax results of that class then available was small and the magnitude of the apparent variations was small, but the latter seemed to be of some significance when compared with the very small probable errors computed for the results of observation. Since the former publication appeared a large number of photographic results have become available. Among them are to be mentioned especially two series, one from PROFESSOR S. A. MITCHELL at the Leander McCormick Observatory and one from PROFESSOR J. A. MILLER at the Sproul Observatory, each of whom has kindly sent a manuscript copy of his results in advance of publication. These additional values have been included with those previously considered and a revised comparison made. The authorities and the extent of the data from each are indicated in the following table. The figures in the last column show the number of independent results of measures made by the respective authorities, that is, exclusive of the result for the second member of a pair of stars or for a comparison star on the same plate with a parallax star.

Observatory	Date	Authority	Reference	
Yerkes (1)	1911	Schlesinger	Aph. J. XXXIV. p28	[illegible]
Yerkes (2)	1913, Nov.	Slocum, Mitchell	A. N. 4709	30
Yerkes (3)	1914	Slocum	A. N. 4760	15
Greenwich	1915, June	Davidson	Mo. Not. LXXV, p595	40
Mt. Wilson	1915, Nov.	Van Maanen	Contributions No. 111	21
Yerkes (4)	1916, Oct.	Lee, Joy, Van Biesbroeck	A. J. No. 697	36
Sproul	1916, Nov.	Miller	In manuscript	60
Leander McCormick	1916, Nov.	Mitchell	In manuscript	94
Dearborn	1916, Dec.	Fox	In manuscript	4
			Total	325

For the present purpose it seems proper to give the results of three series of comparisons, the first nearly independent of the other two, and the second and third largely independent of each other.

First. A series of differences between the results for the components of successive pairs of stars whose members are close together, especially in right ascension.

Second. A series of group means of all the elected photographic parallax results at hand taken by themselves and adjusted for a difference of parallax with respect to proper motion and spectrum; these to be compared between themselves, and also with similar results obtained by other methods and corresponding to the photographic results as near as may be, in distribution, especially in right ascension or season of observation.

Third. A series of differences on individual stars between the mean of the photographic results and the mean of those from all of the selected authorities, including the photographic authorities themselves, which occur on the same individual stars.

First. In a number of cases the difference of magnitude between the members of a pair is considerable and it seemed worth while to compare the differences of parallax with the corresponding differences of magnitude for the successive pairs. For this purpose, of course, only pairs that are physically connected should be selected, such as well-determined binaries, or those whose members have a common motion in space. These restrictions have been observed except that the conventional "proper-motion", thwartwise in the sky, was the only proper-motion regarded. The spectra of the components, when given, were also very nearly the same. The magnitudes were taken from any authority available, mostly from *Burnham's General Catalogue of Double Stars*. These are uncertain and also not photographic; but it was thought the differences for the individual pairs would be near the truth. The data of this comparison are presented in the following table. The differences for each authority are grouped in order of difference of stellar magnitude numbers and the latter are taken in the sense Fainter minus Brighter. The groups are arranged across the page in the order of their mean difference of stellar magnitude. The lowest and the highest values of the mean difference of parallax happen to fall on the fourth and sixth groups respectively, with a difference of 0″.0274. The results of pairs of stars from the four Yerkes series were taken together as one series, divided into three parts, and disposed in the table according to their mean differences of stellar magnitude.

Yerkes		Yerkes		McCormick		Sproul		Yerkes		McCormick	
Diff. Mag.	Diff. Par.	Diff. Mag.	Diff. Par.	Diff. Mag.	Diff. Par.	Diff. Mag.	Diff. Par.	Diff. Mag.	Diff. Par.	Diff. Mag.	Diff. Par.
	″		″		″				″		″
+0.1	−0.015	+0.6	−0.026	+0.2	−0.015	+0.2	+0.005	+1.2	−0.017	+2.2	+0.032
+0.1	− 005	+0.7	− 008	+1.0	− 008	+1.3	− 002	+1.2	+ 020	+2.2	+ 006
+0.3	+ 002	+0.7	+ 010	+1.5	+ 034	+1.5	− 040	+1.5	− 002	+3.0	− 034
+0.4	− 036	+0.8	− 014	+2.1	− 041	+2.7	− 024	+1.7	− 010	+3.1	+ 037
+0.5	+ 013	+1.0	+ 008					+2.	+ 013	+4.4	+ 020
		+1.1	− 012					+2.5	− 009		
+0.28	−0.0082	+0.82	−0.0070	+1.20	−0.0075	+1.42	−0.0152	+1.68	−0.0008	+2.98	+0.0122
n = 5		n = 6		n = 4		n = 4		n = 6		n = 5	

These differences of parallax are small; but the process by which the observed quantities were derived is very closely if not entirely differential, and the results from each plate are based upon identically the same data, presumably, as regards the comparison stars. Of the total of thirty differences eleven are equal to, or greater than, 0″.020 and twenty-one are equal to, or greater than, 0″.010. These proportions in frequency seem large when the smallness of the probable errors computed for these parallaxes in general is considered. The discordances occuring in the list of differences, however, are such that it does not seem probable that there is here any general systematic error due to difference of magnitude.

Second. In the present list of 325 photographic parallax results there are 275 separate stars entered. The components of each pair of stars, such as the members of a binary system and others so close together as to fall upon the same plate, were counted here as one star and represented by the parallax result for the brighter or principal star.

The observed parallaxes all received a slight reduction to absolute parallax. The 275 values of parallax were arranged in order of proper motion and divided into 21 groups with 12 to 14 parallaxes in each group. The mean values of these groups were then computed. The extreme point, $\pi = +0''.191$ for $\mu = 2''.89$, fell decidedly below a straight line which

was first drawn to represent the entire series of points. A straight line was then drawn through the points corresponding to the lowest twelve group means of proper motion and the mean of the points corresponding to the highest four group means.

The resulting equations for the photographic parallaxes and those from the other authorities selected here, are as follows, respectively:

$$\pi \text{ (Obsd.)} = +0''.0400 + 0''.0695 \quad (\mu - 0''.300)$$
$$\pi \text{ (Obsd.)} = +0\ .0400 + 0\ .0978 \quad (\mu - 0\ .100)$$

These equations were adopted in the adjustment of the parallax values on account of proper motion.

The list of 275 parallaxes were next divided into 25 groups of 11 stars in each, in order of right ascension. The mean values for these groups were computed and the residuals, in the sense Mean minus Individual Parallax, were written out. The eight largest negative and the four largest positive residuals seemed unduly large and were excluded. Among the latter were the abnormal cases of *μ Cassiopiæ*, 1h 2m, mag. 5.3, $\mu = 3''.75$, $\pi = +0''.110$, and AOe 14318-20, 15h 5m, mags. 9.6 and 9.2, $\mu = 3''.68$, $\pi = +0''.017$. The remaining 263 parallaxes were then divided into thirteen groups in order of right ascension with 20 to 21 stars in each group, and the group means computed. These were compared with those for YALE and FL. II, which were adjusted in the same manner, except that FL. II received also a slight correction for magnitude equation. These data are given in the first three divisions of the table below. The numbers for YALE are the means, by successive pairs, of the eighteen numbers that enter into the plot of Fig. 1, A. J. 696.

YALE				FL. II				PHOT.				PHOT. – MEAN			
R. A.	Par.	No. of Stars	Residual	R. A.	Par.	No. of Stars	Residual	R. A.	Par.	No. of Stars	Residual	R. A.	Diff.	No. of Stars	Residual
h	″		″	h	″		″	h	″		″	h	″		″
1.1	+0.0516	24	−0.0187	0.9	+0.0377	10	−0.0010	1.0	+0.0380	20	−0.0034	0.8	−0.0066	7	+0.0014
3.4	353	24	− 24	3.2	460	10	− 93	3.0	439	21	− 93	2.6	− 130	7	+ 78
				5.5	504	10	− 138	4.8	437	20	− 90	4.4	− 188	8	+ 136
6.5	419	23	− 90					6.3	268	20	+ 78	6.8	− 130	7	+ 79
				7.6	223	10	+ 144	8.0	252	20	+ 95	7.8	− 009	7	− 43
9.5	116	24	+ 213	9.8	243	10	+ 124	10.3	440	20	− 94	10.4	+ 110	8	− 162
11.8	292	23	+ 37	11.7	593	10	− 227	12.5	200	21	+ 147	13.9	− 064	7	+ 12
14.5	286	23	+ 43	13.9	312	10	+ 055	15.2	312	20	+ 34	16.1	− 134	7	+ 83
				16.0	594	10	− 227	16.8	424	20	− 78	18.0	− 005	8	− 47
17.2	517	24	− 188	17.4	535	10	− 169	18.5	481	21	− 134				
19.9	342	23	− 13	19.4	424	10	− 057	19.7	320	20	+ 26	19.5	+ 153	7	− 205
				21.0	112	10	+ 255	21.0	288	20	+ 59	21.1	− 163	7	+ 111
22.5	+0.0120	24	+0.0209	22.8	+00.022	9	+0.0341	23.0	+0.0262	20	+0.0084	23.0	+0.0006	8	−0.0057
Mn.	+0.0329	212	+0.0502		+0.0367	119	+0.0922		+0.0346	263	+0.0523		−0.0052	88	+0.0513
			−0.0502				−0.0921				−0.0523				−0.0514

The probable error of a single group mean in parallax, computed from an average observed probable error of the parallax result of a single star, is as follows to a close degree of approximation: for YALE, $\pm 0''.0109$, 23 to 24 stars; for FL. II, $\pm 0''.0202$, 10 stars; and for the photographic, $\pm 0''.0044$, 20 to 21 stars.

With these figures in mind an inspection of the series of plotted points gives the impression that the differences in the ordinates are due to some other cause than accidental error of observation. A curve was drawn simply connecting the points for the photographic values. Curves were drawn also for YALE and FL. II but adjusted somewhat to avoid what seemed to be too abrupt changes in the ordinates. Thus drawn the approximate coincidence of all three authorities in two regions of right ascension as to higher parallax and in two other regions as to lower parallax, seems apparent. The numbers involved may be brought together, as in the following table where the parallax means are taken to three decimal places only.

The photographic series include a singular, high point at 10h.3 and FL. II likewise at 11h.7, but no stars are common to the two authorities in those groups. Each of these points is due to several high individual values under their respective authorities. The depression at 20h to 24h is perhaps the most marked coincidence of the three plots. Here YALE has twenty-four stars of which only five are in the FL. II list; FL. II has nineteen stars of which only three are in the photographic list; and the last named has forty stars of which only five are in the YALE list.

Lowest Mean Values of Parallax

Yale	R. A.	Par.	No. of Stars	Fl. II	R. A.	Par.	No. of Stars
	h	″			h	″	
Group 4	9.5	+0.012	24	Mean of Groups 4 and 5	8.7	+0.023	20
Group 9	22.5	+0.012	24	Mean of Groups 11 and 12	21.9	+0.007	19

Highest Mean Values of Parallax

Yale	R. A.	Par	No. of Stars	Fl. II	R. A.	Par.	No. of Stars
	h	″			h	″	
Group 3	6.5	+0.042	23	Mean of Groups 2 and 3	4.4	+0.048	20
Group 7	17.2	+0.052	24	Mean of Groups 8 and 9	16.7	+0.056	20

Photographic

Lowest Mean Values of Parallax	R. A.	Par.	No. of Stars	Highest Mean Value of Parallax	R. A.	Par.	No. of Stars
	h	″			h	″	
Mean of Groups 5 and 7	10.2	+0.022	41	Mean of Groups 2 and 3	3.9	+0.044	41
Mean of Groups 12 and 13	22.0	+0.028	40	Group 10	18.5	+ .048	21

Not only the sequence of the ordinates but the magnitudes of the differences from their respective general mean values attract attention as shown in the following table.

	Prob. Error of a Single Group Mean	No. of Group Means	No. of Res. $> 2r_o$ for Group Means	No. of Res. $> r_o$ for Gr. Means
	″			
Yale	±0.0054	9	4	5
Fl. II	0.0101	12	4	8
Phot.	0.0044	13	6	10

It is possible that these residuals in their frequencies are within the range of probabilities, but not likely. They seem to indicate that for each of the authorities the parallaxes are not distributed at random throughout the hours of right ascension; and also, with reference to the other tables preceding, that there is some cause of systematic variation and this in common in some degree, to the three different series of determinations.

Third. In the fourth division of the principal table above are given the group-mean values of the differences, on the individual stars, between the mean of the photographic authorities occuring on a given star and the mean of all the selected authorities that occur on that star, including the photographic authorities themselves. The authorities not photographic are the same as adopted for the later discussion in *A. J.* 696, namely Yale, Flint II, Abetti, Peter, Jost and Miscellaneous. All of the observed parallaxes received a slight reduction to absolute parallax. Yale was corrected in addition for the supposed small systematic error adopted in *A. J.* 696*; and Fl. II for the small magnitude equation. The differences, in the sense Photographic minus Mean of all, were plotted. A positive ordinate, therefore, corresponds to a higher parallax for the photographic authority. A curve was drawn directly from point to point, except at $19^h.5$ and $21^h.1$ where the mean position of the two points was adopted. With the large increase of data the points naturally run in a smoother series here than in Fig. 10 (*A. J.* 696). The discordant point at $21^h.1$ includes the largest individual difference in the entire list. This is −0″.076 on 3 η *Cephei*, 20^h 43.3^m, +61° 27′. There are three authorities here: Yale, +0″.115; Abetti, +0″.252; and Phot., +0″.070. If the second be omitted the difference of Phot. from Mean

* Logically this correction should not have been made here; but the effect of this oversight upon the numbers in the fourth division of the table must be very slight as, for instance, in the period from $20^h.0$ to $21^h.0$, when there are only five stars in common between the photographic authorities and Yale.

becomes $-0''.023$, and the group mean, the ordinate of the plot, becomes $-0''.0087$. The probable errors cannot be so definitely estimated as for the group means of individual authorities; but again the reality of the wave-like series seems within the range of probability or at least on the border.

The curve for the numbers in the second column of the fourth division of the table would not necessarily be expected to rise and fall with the curve for the numbers in the second column of the third division. This seems evident from the following considerations.

If a high or low point for the third division is due to accidental errors on individual stars the expectation would be for some corresponding excess, but not very marked, in the fourth division; for the stars showing excessive values in the groups of the third division might not occur at all in the fourth division; or, if they do occur, they should not effect the mean of any group materially.

If a high or low point in the third division is due to systematic error peculiar to the photographic results, the expectation would be for a corresponding excess in the fourth division; but if a high or low point in the former is due to a systematic error common to the several authorities, or if it is due to the actual distribution of the stars in space, there would be no expectation of a corresponding excess in the fourth division.

This last curve has the aspect, to some degree, of a reversal of the curves drawn for the three individual authorities. It is smoother in its undulations, although derived from the data on a far less number of stars. An inspection of the curve drawn appears to justify the impression of small yet sensible systematic differences between the results of the photographic method and the mean of the older methods.

There can be no question that the present photographic methods are far superior in accuracy and economy for the determination of individual parallaxes, but it seems possible that when general mean values come into consideration, there will remain some systematic error, although small, which must be taken into account.

Washburn Observatory, Madison, Wisconsin,
1918, February.

OBSERVATIONS OF COMETS,

MADE WITH THE 40-INCH AND 12-INCH REFRACTORS OF THE YERKES OBSERVATORY,

By GEORGE VAN BIESBROECK.

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Instr.
				Comet Metcalf–Borrelly 1919 *c*						
1919	h m s	m s	′ ″		h m s	° ′ ″				
Aug. 25	14 58 52	+0 35.65	+8 9.1	6 , 6	14 7 52.35	+25 59 25.6	9.672	0.673	1	12
27	13 53 25	−0 6.42	+2 26.2	6 , 6	10 57.59	25 12 8.9	9.627	0.640	2	12
Sept. 11	13 43 9	−1 0.45	−1 25.2	10 , 4	37 7.62	18 19 9.6	9.627	0.673	[illegible]	[illegible]
12	13 17 31	−0 14.18	−1 44.3	8 , 8	39 4.49	18 22 54.8	9.605	0.668	[illegible]	[illegible]
20	13 20 52	+0 17.34	−1 52.7	6 , 6	54 57.71	14 41 28.2	9.614	0.706	5	[illegible]
22	13 51 21	+0 19.03	−3 11.4	6 , 6	14 59 12.09	13 13 52.4	9.634	0.729	6	12
25	13 48 54	+1 48.39	+0 13.2	25 , 5	15 5 39.50	12 17 5.0	9.633	0.737	7	12
Oct. 6	13 21 12	−0 28.23	−4 33.4	6 , 6	30 55.58	6 17 11.7	9.621	0.753	8	12
7	13 28 37	+1 46.11	−3 42.5	15 , 3	33 21.56	6 16 6.3	9.623	0.757	9	12
11	12 55 56	+1 44.82	−5 22.6	25 , 5	15 43 16.10	+ 4 11 30.1	9.608	0.759	10	12
Nov. 1	11 57 53	−0 1.21	−2 57.1	6 , 6	16 11 49.21	− 7 10 11.5	9.580	0.797	11	12
11	11 50 46	−0 1.08	+5 31.1	6 , 6	17 13 51.73	−12 39 8.6	9.588	0.811	12	12
13	11 53 30	1 8.36	4 14.8	25 , 5	20 38.28	−13 43 57.5	9.591	0.812	13	12
14	11 44 16	−0 13.04	4 20.9	30 , 6	24 2.07	14 15 52.5	9.585	0.816	14	12
18	11 44 53	−0 11.54	0 13.6	6 , 6	38 2.00	−16 22 52.1	9.592	0.819	15	12
22	11 46 1	−0 28.20	+2 21.6	6 , 6	52 32...	−18 26.6 .	9.600	0.824	16	12

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Instr.
				Comet Brorsen-Metcalf 1919 b						
1919	h m s	m s	' "		h m s	° ' "				
Aug. 25	15 51 53	−0 5.53	+2 44.3	6 , 6	22 37 21.12	+35 51 13.3	9.503n	0.242	17	12
Sept. 7	13 54 14	−1 24.74	−0 41.8	4 , 4	16 19 10.36	76 20 30.6	0.083	0.524n	18	40
10	15 17 12	−0 20.70	−2 16.7	6 , 6	13 40 9.99	68 3 45.2	0.049	0.574	19	40
11	14 31 27	+0 3.73	−5 50.6	6 , 6	13 17 2.09	64 47 2.3	0.000	0.551	20	12
19	14 37 26	+2 45.60	+1 45.6	20 , 4	12 7 58.86	42 57 31.0	9.676	0.844	21	12
20	13 3 19	+0 16.20	+0 36.7	8 , 6	12 4 48.74	41 6 13.6	9.744	0.745	22	12
21	22 37 12	+0 52.14	+4 54.4	10 , 2	12 0 51.06	38 31 49.2	9.718n	0.776	23	12
22	13 33 3	−0 46.67	−6 36.2	25 , 5	11 59 14.46	37 27 1.0	9.691	0.807	24	12
25	13 4 14	+0 38.14	......	6 , .	11 53 15.87	....	9.676	.....	25	12
25	13 4 14	....	+1 37.7	. . , 6	....	32 48 19.6	....	0.803	26	12
Oct. 5	22 11 10	+0 24.29	+4 0.5	8 , 8	11 45 16.22	20 25 14.0	9.662n	0.762	27	12
6	22 43 21	−0 8.36	−0 48.6	6 , 6	11 45 21.58	19 22 11.6	9.661n	0.744	28	12
22	23 24 23	−1 46.04	−0 15.8	25 , 5	12 6 38.06	+ 3 50 43.4	9.605n	0.760	29	12
Nov. 12	23 33 5	−0 8.87	−3 2.4	4 , 6	13 0 4.56	−11 33 32.1	9.567n	0.811	30	12
14	23 19 58	+1 4.14	+0 33.2	30 , 6	13 4 56.84	−12 40 47.2	9.590n	0.810	31	12
17	23 30 40	+0 10.94	−1 21.9	6 , 6	13 12 8.75	−14 17 3.6	9.576n	0.820	32	12
				Comet Kopff 1919 a						
Sept. 12	13 39 7	+0 23.53	−2 54.8	6 , 6	19 45 27.73	− 8 0 39.3	8.841n	0.830	33	12
15	13 49 8	+0 11.00	−5 24.5	8 , 8	48 38.42	− 7 59 23.1	8.532n	0.830	34	12
19	15 8 16	+0 9.54	+4 44.9	8 , 8	53 9.93	57 24.6	9.135	0.827	35	12
20	13 42 28	−0 33.70	−1 22.1	6 , 6	54 19.00	56 50.8	8.302	0.830	36	12
22	15 21 7	−1 56.14	−0 22.8	12 , 6	56 49.64	55 21.9	9.240	0.825	37	12
23	13 17 52	−0 48.05	+0 14.0	8 , 8	57 57.71	54 45.2	8.711n	0.829	38	12
24	13 55 16	+0 28.18	+1 2.3	10 , 4	19 59 13.93	− 7 53 56.9	8.400	0.830	39	40
				Comet Finlay-Sasaki 1919 d						
Nov. 13	13 5 0	−2 2.65	+3 22.3	30 , 6	23 4 12.63	− 8 11 3.7	8.679n	0.831	40	12
14	13 45 2	−3 36.14	−1 38.7	30 , 6	12 54.92	− 6 54 54.0	8.992	0.824	41	12
16	16 41 30	−0 45.65	−1 48.0	12 , 4	30 22.77	− 4 19 30.9	9.482	0.796	42	40
17	13 33 49	+0 11.70	+0 49.8	6 , 6	37 19.90	− 3 17 12.0	8.408n	0.798	43	12
18	12 7 11	−0 10.70	+4 7.6	6 , 6	44 44.99	− 2 10 55.5	9.278n	0.788	44	12
19	14 4 2	+0 11.95	+0 43.4	6 , 6	23 52 56.74	− 0 56 30.9	8.231	0.780	45	40
22	12 29 9	+2 29.26	−1 9.6	25 , 5	0 14 15.97	+ 2 14 27.0	9.244n	0.756	46	12
23	16 39 32	+0 6.29	+2 45.1	6 , 6	0 22 17.26	+ 3 25 50.1	9.422	0.749	47	40
Dec. 14	12 47 0	+1 29.34	+0 39.3	25 , 5	2 6 30.13	+16 51 44.1	9.294n	0.599	48	40
19	12 18 39	+1 45.06	−0 15.5	25 , 5	2 23 33.05	+18 32 36.4	9.386n	0.588	49	12
26	13 51 9	+0 13.12	−0 49.9	6 , 6	2 44 43.83	+20 22 29.9	8.777n	0.520	50	12
28	14 30 47	−0 8.26	+2 29.5	8 , 8	2 55 43.95	+20 48 25.7	8.140	0.509	51	40
				Comet Schaumasse 1919 e						
Nov. 17	23 11 2	−0 0.54	+2 16.9	8 , 8	13 12 48.03	+ 2 38 53.1	9.584n	0.762	52	12
18	22 52 34	−1 27.43	−8 23.8	30 , 5	13 16 9.46	+ 2 22 5.7	9.601n	0.764	53	12
1920 Jan. 1	23 39 55	−0 2.48	+4 0.3	8 , 8	15 24 52.03	− 7 24 4.5	9.481n	0.811	54	40

Comparison Stars

Mean Coördinates for Beginning of Year and Reductions to Apparent Places

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	14 7 14.85	+25 51 16.8	+1.85	− 0.3	Oxf. ph. 25° 42614 − 26° 34888.
2	11 2.16	25 9 42.9	1.85	− 0.2	*A. G. Camb.* 6761.
3	38 6.18	18 50 35.1	1.89	− 0.3	*A. G. Berl. A.* 5302.
4	39 16.48	18 24 39.5	1.89	− 0.4	*A. G. Berl. A.* 5310.
5	54 38.44	11 43 21.2	1.93	− 0.3	Bord. ph. 14°, $14^h 56^m$ No. 13; 15°, $14^h 52^m$ No. 112.
6	58 51.12	13 47 1.1	1.94	− 0.3	*A. G. Lpz. I.* 5277.
7	15 3 49.15	12 16 52.4	1.96	− 0.4	*A. G. Lpz. I.* 5306. Mean of two components.
8	30 25.30	6 51 47.9	2.05	+ 0.2	Tou. ph. 7°, $15^h 32^m$ No. 100.
9	31 33.39	6 19 48.7	2.06	+ 0.1	Tou. 2401.
10	41 29.17	+ 4 16 52.3	2.11	+ 0.4	*A. G. Alb.* 5277.
11	16 41 48.04	− 7 7 50.0	2.41	+ 2.6	Anon. referred to *A. G. Ott.* 5769.
12	17 13 48.06	−12 44 43.9	2.59	+ 4.2	Anon. referred to *ν Serpentis* (Boss *P. G. C.* 4395).
13	21 44.02	−13 48 7.9	2.62	+ 4.4	*A. G. Harv.* 5950.
14	24 42.47	−14 11 36.2	2.64	+ 4.6	½ *A. G.* (*Harv.* 5967 + *Wash.* 6263).
15	38 10.83	−16 22 13.7	2.71	+ 5.2	Anon. referred to *A. G. Wash.* 6364.
16	17 52 1...	−18 29.1 ..	2.79	+ 5.9	*B. D.* −18° 4703 ($9^M.0$).
17	22 37 22.26	+35 48 5.4	+4.39	+23.6	*A. G. Lu.* 10826.
18	16 20 38.22	76 20 56.8	−3.12	+15.6	Grw. ph. 76° 5565.
19	13 40 32.30	68 6 4.1	−1.61	− 2.2	Grw. ph. 68° 1832.
20	13 16 59.32	64 52 57.9	−0.96	− 5.0	½ *A. G.* (*Chr.* 1997 + *Hels.* 7532).
21	12 5 12.15	42 55 58.3	+1.11	−12.9	*A. G. Bo.* 8367.
22	12 4 31.36	41 5 50.0	1.18	−13.1	*Kü.* 5369.
23	11 59 57.63	38 27 8.3	1.29	−13.5	*A. G. Lu.* 5337.
24	11 59 59.81	37 33 50.9	1.32	−13.7	*A. G. Lu.* 5338.
25	11 52 36.23	32 39 14.3	1.50	−14.4	*A. G. Lei.* 4548.
26	11 54 9.34	32 46 56.2	1.49	−14.3	*A. G. Lei.* 4554.
27	11 44 50.10	20 21 28.9	1.83	−15.4	Par. ph. +21°, $11^h 40^m$ No. 62; $11^h 48^m$ No. 82.
28	11 45 28.09	19 23 15.7	1.85	−15.5	*A. G. Berl. A.* 4532.
29	12 8 21.96	+ 3 51 13.9	2.14	−14.7	*A. G. Alb.* 4447.
30	13 0 10.91	−11 30 16.9	2.52	−12.8	*A. G. Harv.* 4687.
31	13 3 50.13	−12 41 7.8	2.57	−12.6	*A. G. Harv.* 4706.
32	13 11 55.18	−14 15 29.4	2.63	−12.3	*B. D.* −13° 3680 ($9^M.5$) referred to *A. G. Harv.* 4756.
33	19 45 0.20	− 7 58 3.1	4.00	+18.6	*A. G. Ott.* 6935.
34	19 48 23.45	− 7 54 17.4	3.97	18.8	*A. G. Ott.* 6955.
35	19 52 56.45	− 8 2 28.7	3.94	19.2	*B. D.* −8° 5174 referred to *A. G. Ott.* 6977.
36	19 54 48.77	− 7 55 48.1	3.93	19.4	*A. G. Ott.* 7012.
37	19 58 41.86	− 7 55 18.9	3.92	19.7	*A. G. Ott.* 7044.
38	19 58 41.86	− 7 55 18.9	3.90	19.7	*A. G. Ott.* 7044.
39	19 58 41.86	− 7 55 18.9	3.89	19.7	*A. G. Ott.* 7044.
40	23 6 11.29	− 8 14 51.6	3.99	25.6	*A. G. Ott.* 8232.
41	16 27.04	− 6 53 41.4	4.02	26.1	*A. G. Ott.* 8287.
42	31 4.35	− 4 18 9.6	4.07	26.7	*A. G. Strb.* 8093.
43	37 4.11	− 3 18 28.7	4.09	26.9	*A. G. Strb.* 8117.
44	44 51.57	− 2 15 30.1	4.12	27.0	Alg. ph. −2°, $23^h 44^m$ No. 72.
45	23 52 40.64	− 0 57 41.5	4.15	27.2	*A. G. Nic.* 5922.
46	0 11 42.47	+ 2 15 9.1	4.24	27.5	*A. G. Alb.* 35.

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
47	0 22 6.67	3 22 37.6	4.30	27.4	*A. G. Alb.* 79.
48	2 4 55.79	16 50 41.3	5.00	23.5	*A. G. Berl. A.* 606 + p. m.
49	2 21 42.86	18 32 29.7	5.13	22.2	*A. G. Berl. A.* 673.
50	2 44 25.42	20 22 59.6	.9	20.2	Par. ph. +21°, 2^h 44^m, No. 106.
51	2 55 46.84	20 45 37.2	5.37	+19.0	Par. ph. +21°, 2^h 52^m, No. 87.
52	13 12 46.16	2 36 52.0	2.41	−15.8	*B. D.* +2° 2654. 4 obs. *Abbadia*
53	13 17 34.17	+ 2 30 45.1	2.42	−15.6	Boss *P. G. C.* 3459.
54	15 24 54.48	− 7 28 6.5	0.03	+ 1.7	*A. G. Ott.* 5407.

REMARKS

These observations are continued from *Astron. Journal* No. 756.

☄ 1919 *c*

Aug. 25 Total brightness $9^M.5$.

Aug. 27 Round nebulosity about 2′ in diameter. Sharp settings on central condensation. Total brightness $9^M.1$.

Sept. 12 Small round nebulosity with 12^M central nucleus. Total brightness $9^M.0$.

Sept. 25 Total brightness $8^M.5$.

Oct. 6 Difficult in bright moonlight.

Oct. 11 Sharp nucleus. Total brightness $8^M.0$.

Nov. 13 Sharp nucleus 10^M. Total brightness $7^M.5$.

Nov. 22 Sharp nucleus. Diameter of nebulosity 1½′. Total brightness $7^M.0$. Low altitude.

☄ 1919 *b*

Aug. 25 Diameter 4′.5. Faint diffuse condensation. Total brightness 10^M.

Aug. 27 Diameter 6′; diffuse nucleus. Total brightness = B. D. 44 4129 = $9^M.1$.

Sept. 20 Faint tail in position angle 355 about 25′ long.

Oct. 5 Sharp central nucleus. Straight tail in position angle 332°, at least 1° in length, just visible to naked eye. Total brightness $5^M.0$.

Oct. 22 Nebulosity much smaller with sharp nucleus.

☄ 1919 *a*

Sept. 12 Diameter about 3′. Central condensation $12^M.5$. Total brightness $11^M.5$.

Sept. 20 Nebulosity 2′ in diameter. Total brightness $12^M.0$.

☄ 1919 *d*

Nov. 13 Nebulosity 5′ in diameter. Sharp central condensation. Total brightness $8^M.5$.

Nov. 18 Total brightness $8^M.5$.

Nov. 22 Sharp nucleus 12^M. Total brightness $8^M.5$.

Dec. 14 Nebulosity 2′ in diameter. Unsharp nucleus. Total brightness 11^M.

Dec. 28 Faint nebulosity, only 13^M total brightness.

Williams Bay, Wisconsin,
Sept. 14, 1920.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y. Associate Editors, E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward
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PERSONALITY IN THE ESTIMATION OF TENTHS,[1]

By SEBASTIAN ALBRECHT.

Introduction

Other things being equal coarsely divided scales can be read much more rapidly but also much less accurately than scales that are finely subdivided. When only a small amount of measuring is to be done the requirement of speed is usually of minor importance, and we can employ either scales which are amply subdivided so that even a rough estimation will fully meet all feasible requirements of accuracy or a movable micrometer thread with which to measure fractional parts of scale-intervals. For an extensive set of measures, however, the speed of measurement assumes an importance more or less comparable with that of accuracy. In extreme cases, in fact, accuracy must of necessity become of secondary importance in order to make the project possible at all. Thus, for an extensive piece of work the designer of an instrument will be required to exercise his judgment in striking an efficient balance between these two factors. Speed can best be gained by reading the scale directly without any auxiliary settings on scale divisions, the fractional parts of scale-intervals — preferably tenths — being obtained by estimation. Thus one of the important elements to be considered is the degree to which these estimations are dependable. The present paper deals with this factor.

In estimating the position of an index between two scale rulings to tenths of the scale interval personality plays an important part. The list of percentages giving the frequency with which each tenth is represented in the estimations made by an observer has been called by Pierce the observer's personal scale. In connection with the design of measuring scales for a special instrument it seemed to me particularly desirable to know the magnitude and nature of the errors to be anticipated due to the personal scales of the measurers. So, also, the personal scale may assume an unusual prominence on instruments where each setting is individually important, as perhaps in the settings necessary in pointing a big gun. Very little has been published on the personal scale, but its importance seems to have been early recognized by Pickering[2] who introduced an experiment in his regular laboratory course in Physics at the Massachusetts Institute of Technology, which aimed to familiarize his students with the relative positions of index and adjacent scale rulings for each tenth of the scale-interval. For a few observers personal scales have been published.[3]

The subject is treated under three headings: Part I deals with personal scale obtained from observations made in connection with the regular program of meridian circle observations, *i.e.*, estimations of tenths on the telescope and circle micrometers[4] and on thermometer scales; in Part II, estimations made on specially drawn scales are discussed; and Part III contains a few supplementary remarks. The results are given below in condensed form, and only those points are touched upon which seem to have a practical bearing on the estimation of tenths. I believe, however, that the complete data contain material for a study of more detailed though perhaps less directly applicable forms of personality — of more particular interest perhaps to the psychologist.

[1] This paper was in part presented at the meeting of the American Astronomical Society at Harvard in 1918. Abstract in *Pop. Astron.* 26, 637, 1918.

[2] "Physical Manipulation" by E. C. Pickering, second edition, 1875, (p. 27).

[3] S. D. Townley, Astronomy and Astrophysics, June 1892; F. Schlesinger, *Publ. of the A. S. P.*, 15, 207 and 228, 1903; R. G. Aitken, ibid., p. 220; Joel Stebbins, ibid., 17, 75, 1905; Otto Klotz, Jour. R. A. S. of Canada, May-June, 1919.

[4] The larger part of the estimations were made on the eight circle micrometers, the readings being taken directly from the micrometer heads without the use of magnifying glasses. For possible future reference it may be well to note that in 1913 the original metallic scales were replaced by white celluloid scales with blackened graduations. The scale interval is 1.6mm ±, and the present width of rulings is 0.12mm ±. Only records which are (or are equivalent to) single settings can be used for this purpose.

Part I. Personal Scale of a Number of Albany Observers

The data discussed in Part I pertain principally to sixteen present and former observers of the Dudley Observatory, extending over various periods of time, in one case over thirty-nine years. They are therefore suited to drawing inferences as to the degree of constancy or of progressiveness in trend in individual personal scales. Published data will also be drawn upon to some extent. If the individual estimations are tabulated as shown in Fig. 1, which is self-explanatory, each horizontal line furnishes a visualized picture of the personal scale, the "smoothing out" process incident to the means of large numbers of observations is avoided, and appreciable changes in a personal tendency, either gradual or abrupt, will show up promptly. This method will also indicate to what extent samples only need be taken in tabulating a long series of estimations. The individual personal scales are given graphically by the curves in Figs. 2 to 30. The epoch is 1909–10 unless given otherwise. The tables of mean percentages upon which the graphs are based are not published because they can be taken directly from the curves with ample accuracy for most purposes. The detailed tables can be made available, in manuscript form, to anyone who may have use for them.

1915, Feb. 19	0	1	2	3	4	5	6	7	8	9	Total No
H Jenkins											
Stars 3–54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200
55–107	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200
108–157	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200
158–212	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200
213–266	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200
%	17.1	15.9	11.2	6.6	8.5	2.3	6.2	8.1	15.8	8.3	100.0

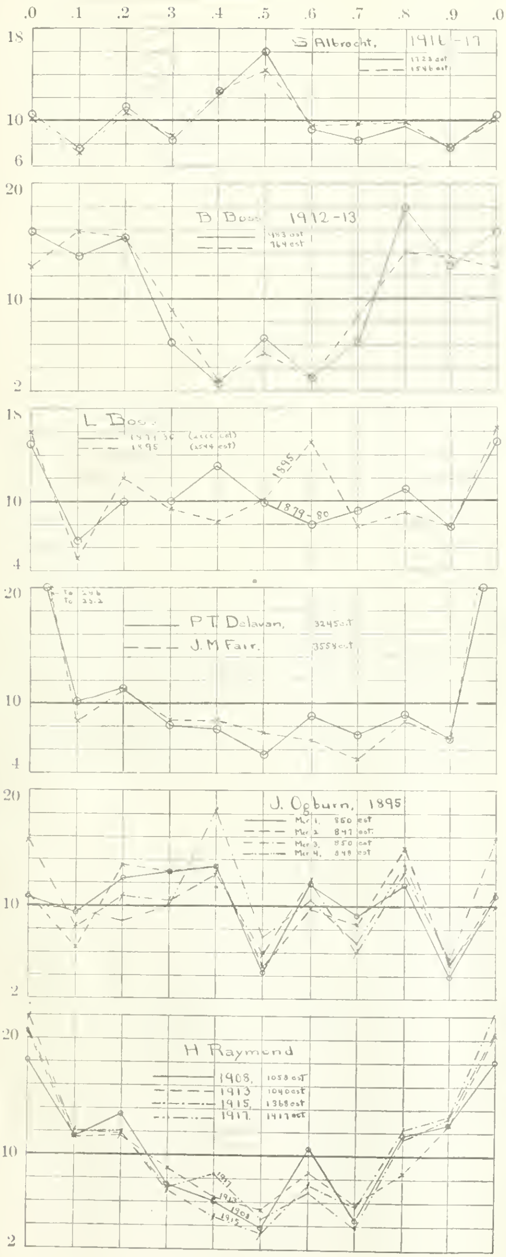
Fig. 1

The actual positions of the index which represent the several tenths in the estimations of any observer can be quickly approximated graphically by laying off on a horizontal line successive distances equal to the percentages with which the successive tenths are represented in the estimations, and then reading off the distances of the centers of these sections from the center of the zero section. This will give approximate values only because it assumes symmetry about zero for the scale as a whole, which is seen (Figs. 2 to 30) to be approximately true, and symmetry within each section about its center, concerning which no evidence is adduced below.

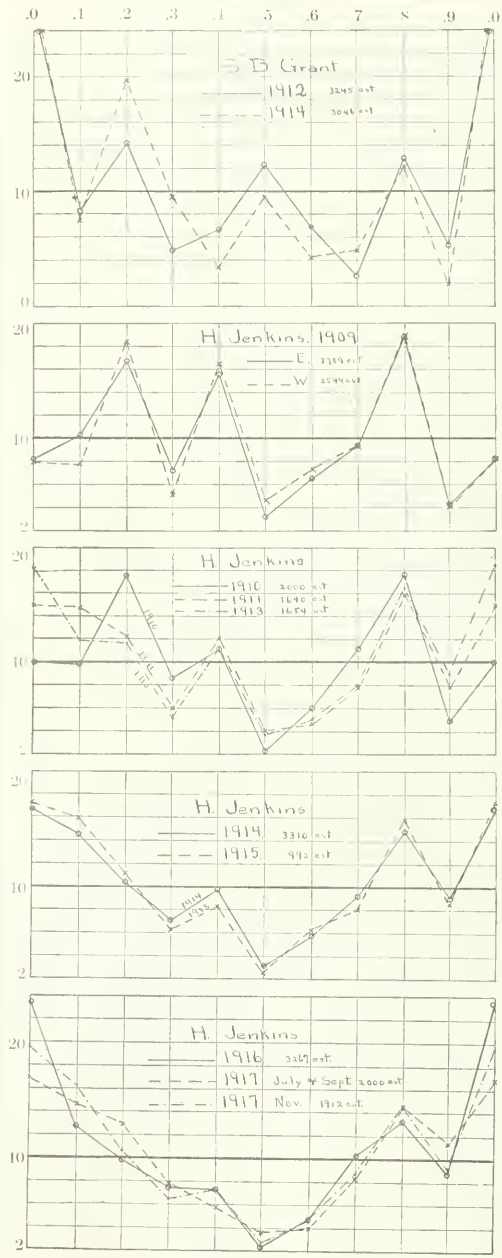
From Figs. 1 to 30, supplemented by the detailed tabulations, a number of interesting deductions may be drawn, the more important of which are the following:

1. The regularity (see Fig. 1) with which successive tabulations at a common epoch duplicate the irregularities appearing in a personal scale shows quite clearly that very little, if any, smoothing out between tenths is permissible. Thus, the curves in Figs. 2 to 30 are merely graphs intended to visualize at a glance the personal scales represented. Adjacent points are connected by straight lines. That is, the percentages by which the different tenths are represented are more or less isolated in character. They are not absolutely independent, however, because if one or more tenths are favored then necessarily also one or more of the remaining tenths *must be* slighted.

2. The personal scales for different observers may differ widely from each other. While one observer may favor some particular tenth or tenths another may slight these and favor others. Note, for example, that the 0.5 is neglected as extensively by M. L. Roy, Mearns and Jenkins (Figs. 16, 13, 9 to 12) as it is favored by A. J. Roy and Albrecht (Figs. 14, 15, 2). Some curves zigzag up and down, see especially Figs. 6, 8, 9, 14 and 15. Other curves follow along with a remarkably uniform smoothness, as in Fig. 13. The most striking feature of the personal scales is the almost universal favoritism for the zero tenth. All of the twenty-two observers whose personal scales are available give the zero more than the normal 10 per cent of the estimations, with the exception of A. J. Roy in 1916–17 (Fig. 15) and Jenkins in 1909 (Fig. 9). The sixteen Albany observers give the zero an average of 19 per cent, and the remaining observers an average of 17 per cent. There is no tenth which is slighted as universally or in approximately the same degree as the zero is favored. In the means for all of the Albany observers (Fig. 27) the central five positions (0.3, 0.4 0.5, 0.6, and 0.7) are somewhat neglected; the 0.2 and 0.8 are only slightly favored; and, perhaps contrary to general expectations, the 0.1 and 0.9 are not much neglected. However, this curve has a very restricted application, the large and varied individual deviations from it being relatively more important in practice.



FIGS. 2 TO 7



FIGS. 8 TO 12

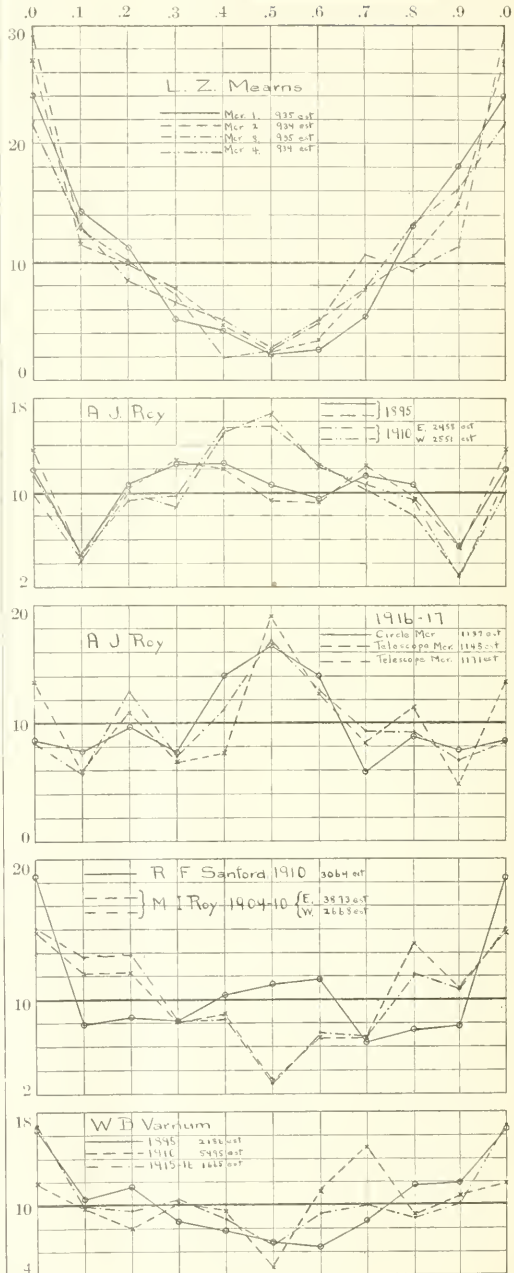
3. Most of the curves are essentially symmetrical with respect to 0.0 and 0.5 — see especially Figs. 3, 13, 18 to 25, 28[5] and 29. Some of the curves, though more or less balanced show a decidedly unbalanced preference or neglect for one or two of the tenths — see, for example, the partiality to the 0.6 by L. Boss in 1895 (Fig. 4), and the neglect of the 0.6 and the persisting preference for the 0.8 by Jenkins through the period from 1909 to 1917 (Figs. 9 to 12). A slight dissymmetry between the low and the high tenths is found in some of the curves. Thus, the curve of Ogburn (Fig. 6), which is in other respects very good, shows a total representation of 46 per cent for 0.1, 0.2, 0.3 and 0.4 and only 37 per cent for 0.6, 0.7, 0.8 and 0.9.

4. For any individual observer the personal scale is constant to a remarkable extent over both short and moderately long periods of time, usually even up to a year. For very short time-intervals this constancy is brought out quite forcibly in the detailed tabulations arranged, as illustrated in Fig. 1, to show up immediately any decided change. For moderately long periods it is best illustrated by the agreement of the curves for circle E and circle W — which involve intervening time-intervals of weeks or even of many months — for Jenkins 1909 (Fig. 9) and for M. I. Roy (Fig. 16); see also Figs. 11 and 12. However, in one instance, that of Tucker (Figs. 18, 19 and 20) the scale changed very markedly within less than a year.

5. Fatigue appears not to change the personal scale appreciably. For example, it remained essentially constant during five hours of continuous observing at great speed, as is illustrated in Fig. 1.

6. For some observers the personal scale changes very little over long periods of time. That of Raymond (in Fig. 7) remained the same, except for minor changes, for the entire period of nine years which the observations cover. Aside from the large increase for the zero tenth the scale of Schlesinger (Fig. 28) was only slightly changed in the interval of five years. For other observers the personal scale may undergo gradual and more or less progressive changes in the course of years. This is bes tillustrated by the scale for Jenkins, eight separate annual determinations of which are available (Figs. 9 to 12) within a total period of nine years. See also the nine determinations for Tucker (Figs. 18 to 25) covering a period of 39 years. The epoch is perhaps the most important consideration in discussing a personal scale. Thus, the changes in Tucker's scale are not especially related to change of location and of instru-

[5] Professor Schlesinger kindly communicated his 1907 scale to me by letter.



Figs. 13 to 17

ment (similar in kind) but to the epoch of observation. Therefore, averaging, *i. e.*, smoothing out between widely separated epochs, is not allowable except for scales which have been shown to have remained constant during the time-interval in question.

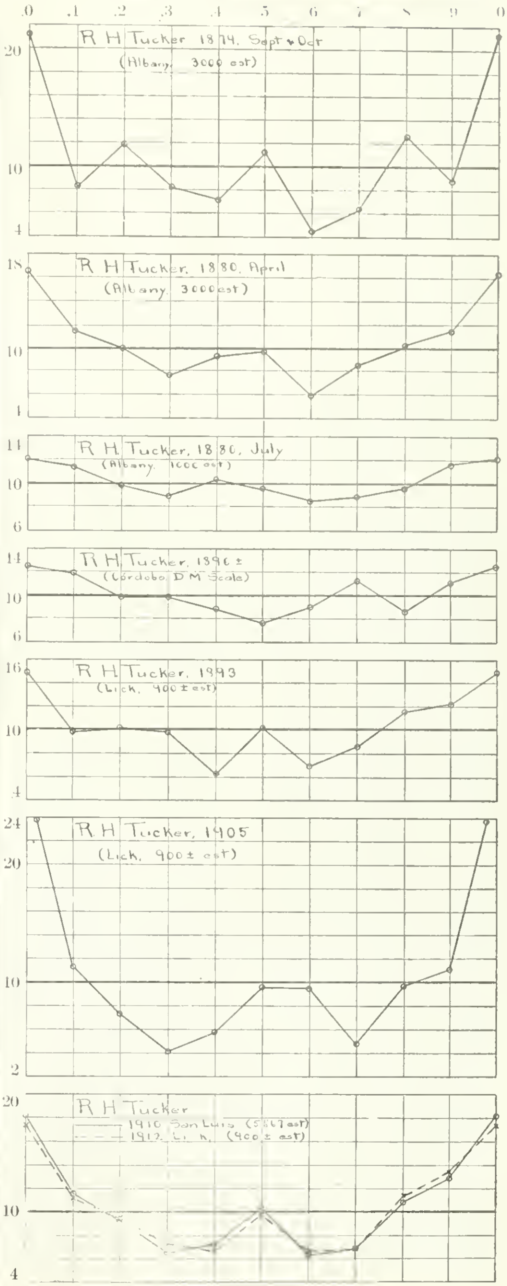
7. As a rule certain persisting tendencies stand out even through marked progressive changes for the scale as a whole. Note the persisting tendency to favor the 0.8 in the radically and progressively changing scale of JENKINS (Figs. 9 to 12); also the strong tendency toward a normal (*i. e.*, 10 per cent) representation for the 0.5 through the 39 years covered by the data for TUCKER (Figs. 18 to 25).

8. When the 0.5 positions on the scale are also marked by (short) graduations the problem becomes to a large extent that of estimating fifths. This is well brought out in the estimations of tenths of degrees on thermometer scales on which the half-degrees are also graduated. Compare the estimations by JENKINS for γ and T (Fig. 31) with his curves for the same epoch in Figs. 11 and 12. The graduations at 0.5 have practically the same representation in the estimations as the main graduations.

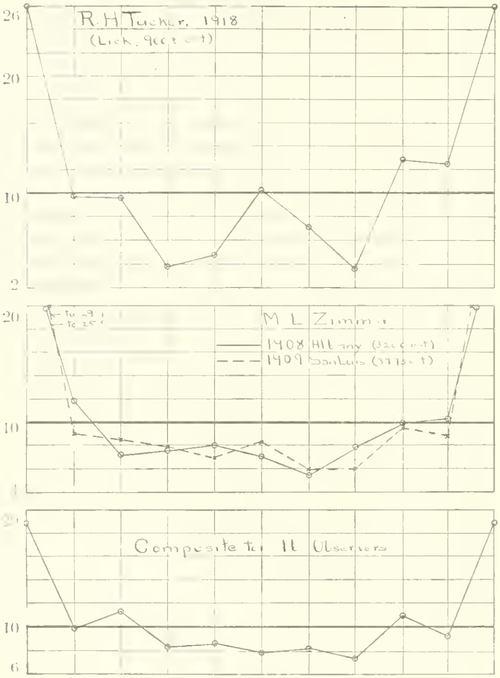
9. Personal scales may be subject to minor variations, depending upon the orientation of the scale relative to the observer's position. Thus, for some observers the results from the four circle microscopes (taken separately) differ somewhat among themselves, the difference being moderately well defined. This effect may deserve somewhat closer study. The widths of the rulings also seem to influence the estimations, as will be shown in Part II.

PART II. ON SPECIAL SCALES

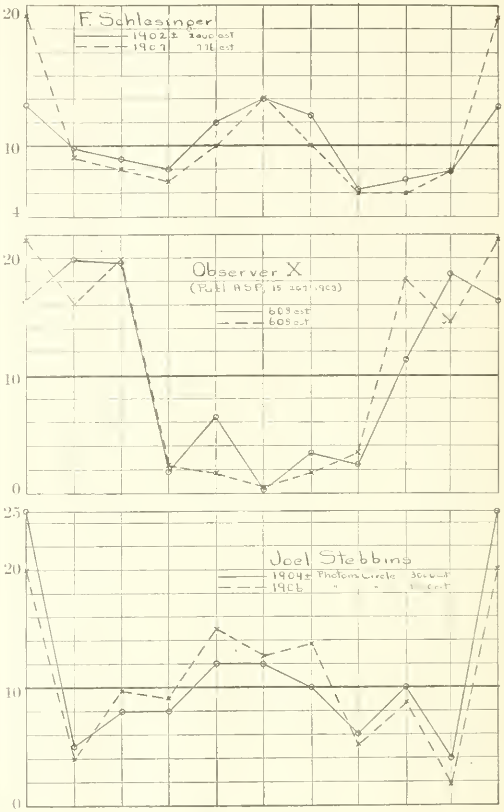
During the progress of the work on personal scales, discussed in Part I, it seemed probable that some persons are influenced in their estimations to a considerable extent by the widths of the scale rulings. The effect seemed to enter in a more or less unconscious tendency to judge the tenths in part by the clear spaces on the two sides of the index rather than by the relative distances between median lines of the index and the adjoining scale divisions. The most obvious result of such a tendency is to produce a deficiency in the total representation of the central tenths and to overemphasize the zero and in some cases the adjoining tenths (0.1, 0.2, 0.8, and 0.9). Thus a pronounced tendency of this kind would offer a plausible explanation for personal scales in which



FIGS. 18 TO 24



FIGS. 25 TO 27



FIGS. 28 TO 31

the zero is very strong; also, in part, for scales in which the 0.0, 0.1, 0.2, 0.8 and 0.9 are all strong and the five central tenths are very weak, an extreme case of the latter kind being the scale of observer X in Fig. 29. The almost universal preference for the zero (see Part I) suggests the possibility that perhaps very few observers, if any, are entirely free from such a tendency. It was readily found in some preliminary tests, and was especially pronounced in a most careful and particular observer, persisting even after his attention had been especially drawn to this point. For example, with very wide lines this observer estimated measured positions of 0.15 and 0.18 as 0.04 or 0.05 and rounded them off to 0.0.

It would seem that an effect of the nature described above should be a minimum with very narrow rulings, because then the ratio of the two clear spaces will approximate closely to the ratio of the distances referred to the median lines of the rulings. It should become more pronounced — probably within limits — with increasing widths of index and scale rulings. Although the use of suitable mechanical devices would be a convenience this effect can also be studied by means of specially drawn scales with rulings ranging in width from relatively fine to very wide. Such scales, with numerous fixed indices drawn in, have the merit that they allow of a direct intercomparison of the relative positions of the index for the several tenths and can be submitted for estimation at different epochs and to any number of observers, the estimations to be compared with measured positions of the indices. Although the subject has not been followed to its logical conclusion in every detail, nevertheless sufficient has been done to warrant the brief account which follows.

A number of special scales were constructed and used. Those most extensively employed, designated by the letters F, F', G and G' were ruled in india ink on Watmann's drawing paper. The two series of

indices F and F' are respectively below and above a common series of graduations having a constant width of 0.06 of an interval. Similarly G and G' are series of indices one below and the other above a set of rulings which have the constant width of 0.20 of an interval. The uniform scale interval is 4.2^{mm}. (1/6 inch). The four sets of indices are as nearly similar to each other as it was possible to draw them with an ordinary ruling pen. In each set the indices, 159 in number, range in width from 0.05[6] or 0.06 to 0.60 of a scale interval, *i. e.*, from a little

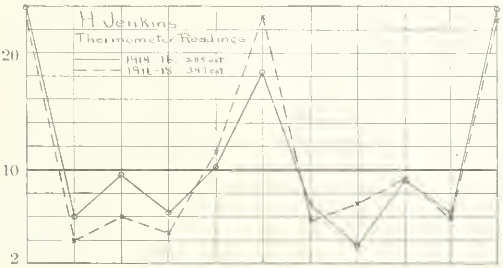
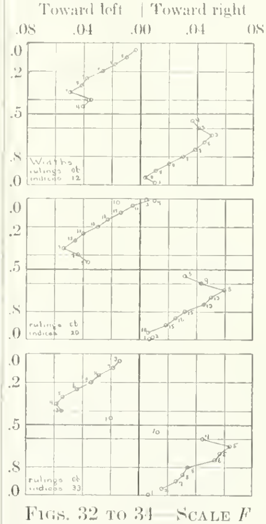


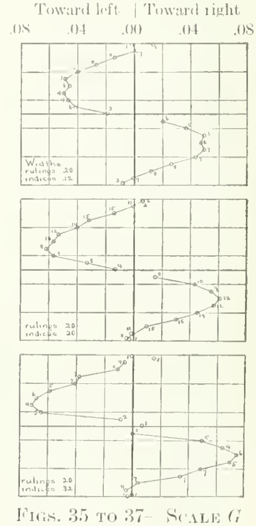
Fig. 31

over 0.2^{mm} to 2.5^{mm} (0.01 in. to 0.1 in.). While estimating a sheet of paper with a small rectangular aperture was used to cover all parts of the scales except the particular index which was being estimated and one scale ruling on each side of it. The scales were estimated twice in both direct and reversed positions, with an interval of a few days between the two sets of estimations. Thus each index was estimated four times, but in the reversed position a 0.1 becomes a 0.9, etc., and the position is changed from below to above the scale rulings or vice versa. The estimations were made to hundredths of an interval, the second decimal being roughly and quickly approximated. The actual time taken for one complete set of estimations (318) on each scale was 30 minutes, which allowed an average of 5.6 seconds per estimate, including the time necessary to shift the small rectangular aperture after each estimate. Only my own estimations and those of Mr. Jenkins have been completely discussed. The estimations by Jenkins are especially suitable for tests of this kind because his habits of estimating are such as to leave his personal tendencies practically free from unusual or temporary disturbing influences.

Three series of graphs were made, each of which was to serve a specific purpose. In the first the individual differences between the estimated and measured positions of the indices were plotted, a separate graph being made for each small range of widths and also for the "direct" and the "reversed" positions of the scales. Displacements toward the left or right of the measured positions were used as abscissæ and the positions of the indices counted from the nearest ruling toward the left as ordinates, increasing downwards. The average widths of indices for these graphs are 0.06, 0.10, 0.17, 0.20, 0.24, 0.33, and 0.53, in terms of scale interval. The purpose of this set of graphs was to show, for any width of lines, how the displacements vary with the distance. In the second series one graph was made for each step of 0.05 in the position of the index, the necessary quantities being taken from the first set of graphs. These were to bring out clearly, for each fixed position of the index, the changes in the displacement dependent upon increasing width of index. The third set, which is reproduced in figures 32 to 45, is a condensed from



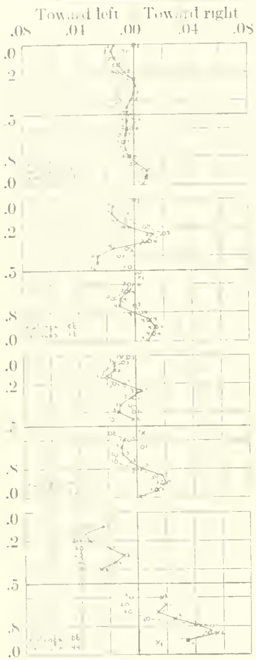
Figs. 32 to 34—Scale F



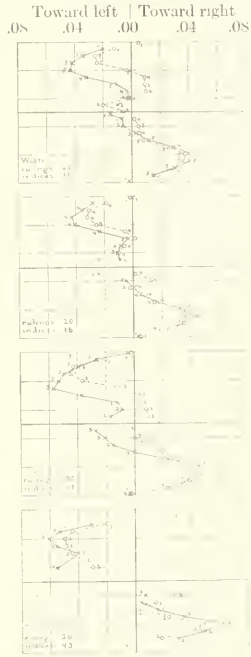
Figs. 35 to 37—Scale G

of the first. It comprises separate graphs for the larger groupings of "narrow," "intermediate," and "wide" indices, for both the narrow and the wide scale rulings. In the graphs for Jenkins (Figs. 32 to 37) results for "direct" and "reversed" are combined. In those for Albrecht (Figs. 38 to 45) separate curves are drawn for indices above and for indices below the scale. The data are insufficient to show whether differences of a systematic nature, which apparently must be of a lower order of magnitude, exist depending upon the position of the index above or below the scale.

[6] On some of the other scales widths down to about 0.02 were used.



Figs. 38 to 41—F and F'



Figs. 42 to 45—G and G'

The following summary contains the principal results derived from the data described above:

1. Both observers have a definite and pronounced tendency — differing from each other considerably in detail, however, — to estimate too close to the nearer of the adjacent scale rulings; *i. e.*, toward the left in the left (*i. e.* first) half of the scale interval and toward the right in the right half. The regularity with which this may occur is well illustrated by the results for Jenkins, which show 397 estimations too close to the nearer ruling, 6 agreeing exactly with the measured positions, and only 35 too far from the nearer ruling. The almost universal preference for the zero tenth, found in Part I, may have its explanation in a rather general tendency to estimate too close to the nearer ruling.

2. This tendency is essentially the same (within moderate limits) for index above as for index below the scale rulings, thus making it practicable for most purposes to combine the results for "direct" and "reversed" positions.

3. For both observers the amount of the displacement varies considerably with the distance of the index from the rulings. For Jenkins the tendency is quite regular, appearing shortly after the index leaves the position of coincidence with the scale division, increasing progressively to a maximum at about the distance of 0.35, and dropping off more abruptly toward the position midway between rulings. In the second half of the interval this trend is repeated in inverse order, coming up rapidly to a maximum at about the position 0.65 and dropping off more slowly again as the next ruling is approached. In my own estimations this tendency is not as regular nor as uniformly progressive as in those of Jenkins. Apparently individual differences of secondary and perhaps even of prime importance must be anticipated.

4. The tendency to estimate too close to the nearer ruling varies also with the width of the index, as is well illustrated in the figures. For Jenkins the change with width of lines is apparently of secondary importance, the displacement toward the nearer ruling being pronounced even for narrow widths and increasing only moderately with wider lines. In my estimations the displacements are slight for narrow lines but with wide lines reach values of about the same magnitude as for Jenkins.

5. In certain cases a very slight tendency has been found, in magnitude of a lower order than the effects enumerated above and superimposed upon them, to estimate sytematically to one side, for example to the left, for practically all positions of the index. This effect is illustrated in Fig. 38 where it is equal to about one-half of one per cent of a scale interval. It is present also in some of my estimations on other scales. It is apparently absent in the curves for Jenkins. From the fairly close approximation to symmetry about zero which was found for all the personal scales (in Part I) it seems reasonably certain that this last mentioned effect must be usually either very slight or entirely absent.

Part III. Supplementary Remarks

(A) An observer's early estimations are apt to be more or less restrained by unusual care taken and by conscious effort. When the operation of estimating has become practically automatic the inhibiting influences are absent and the observer's natural tendencies are brought out. Two interesting practical questions are raised in this connection: First, can very pronounced peculiarities in a personal scale be greatly and safely reduced by frequent practice — only a few minutes at a time — in fixing in mind the correct relative positions of index and scale rulings for each tenth and, second, to what extent can persons with no previous experience in estimating tenths

readily acquire and retain a true personal scale? The results in Part II show that these questions must be answered with reference to particular widths of rulings and index, and that therefore practice scales should have scale-interval and widths of lines similar to those in the scale to be estimated. These questions were taken up to the extent indicated below.

Practice scales were constructed showing the positions, correct to within 0.01 of an interval, for each tenth and twentieth. Tests were applied to only two observers with considerable previous experience. Both were able to familiarize themselves with the scales in three practice periods of about 15 minutes each, and were then able to correctly estimate tenths taken at random with only an occasional error as large as a tenth.

The practice scales were also given to three assistants who had had no previous experience in estimating tenths. They devoted about 15 minutes per day for three successive days in familiarizing themselves with the true scale, after which they made their first independent estimations on similar scales but with the indices drawn in at random. They were allowed to refer to their practice scales at will, of which privilege they availed themselves only occasionally after the first day. It was found that each of these observers estimated correctly to within one-twentieth of an interval. The estimations were all made without any hesitation.

After an interval of two years, during which time no estimations of the positions of indices were made, two of the three observers referred to in the preceding paragraph made additional sets of estimations. They were first given the practice scales for a two-minute period of practice in judging the relative positions of index and scale-rulings for each tenth of the scale-interval. Then independent estimations were made, followed by another two minute practice period, which in turn was followed by more estimations. The scales estimated had widths of lines equal to one-thirtieth of the scale-interval. The estimations were made very rapidly and without any reference to the practice scales. Positions of the index which differed by one one-hundredth of an interval or less from an exact multiple of one-tenth were generally estimated correctly. Thus, for one of the observers eighty-nine per cent of 55 such exact tenths were estimated correctly and eleven per cent were in error by one-tenth, the estimations being made to tenths. For all positions of the index the results of the other observer may be quoted. Eighty-five per cent of this observer's estimations, recorded to the nearest twentieth of an interval, were correct within one-twentieth of an interval, and her largest differences estimated minus measured were .10. Personality is clearly evident in the estimations of both observers, but it is superimposed upon a good degree of accuracy. Both show a definite tendency, similar to that illustrated in Figs. 32 to 45 for JENKINS and ALBRECHT, to place the estimations slightly too near the nearer of the two scale rulings, the amount of the displacement varying also, as in the illustrations, with the distance of the index from the rulings.

As far as these meager trials go they seem to indicate the practicability of acquiring a nearly true personal scale with a very limited amount of practice. Apparently PICKERING had arrived at a similar conclusion. To quote from his text (l. c.), "By practice one can read these fractions (tenths) almost as accurately as by a vernier." It also seems likely that such an acquired scale can be retained by referring to the practice scales for a minute or so before beginning a day's measures, and by an occasional reference to them during the measures. For observers with previously acquired habits greater caution may be necessary to prevent backsliding. The acquisition of a true scale may be especially desirable and practicable in an extensive measuring program. In such a program the practice scales should be employed principally in the acquisition and retention of a nearly true scale, while the actual personal scales of the observers should be determined at appropriate intervals from the observations themselves. Also, where a slide-rule is employed extensively the use of suitable practice scales may increase considerably, in some cases, the accuracy of the individual readings without any loss of speed.

(*B*) The subject of applying corrections for personal scale I approach with considerable misgivings, because unless due caution is exercised in each individual case it may lead to considerable additional labor with only moderate or unimportant gains in the individual results, or possibly even to the introduction of small systematic effects. However, when proper precautions have been taken there can be no more objection to corrections for personal scale than, for example, to the numerous corrections for personal and instrumental effects which are regularly determined and applied in the determination of stellar positions with the meridian circle. The question as to whether such corrections should or should not be applied may be summarized as follows:

Corrections for personal scale should *not* be applied:

(*a*) In all cases where they are not worth while. This may be the case either where the required accuracy for the individual estimations is amply met by a

rough estimation of tenths, or where the inaccuracies of estimation largely disappear in averages, as perhaps in meridian circle zenith distances which are obtained from readings on four micrometers.

(*b*) In all cases where there is danger of thereby introducing systematic effects into the results.

Corrections for personal scale *should be* applied — after having made reasonably certain that no systematic effect would be introduced:

(*a*) When the resulting gain in the accuracy of the individual readings would be a decided advantage, and

(*b*) When thereby a systematic effect would be actually eliminated. This may be illustrated by the following suppositious case: Suppose that in a particular piece of work the diameters of star disks on photographic plates were determined by the estimation of tenths of the scale-interval on a small [illegible] scale in the observing microscope. Then the estimations for all star images of any given diameter would contain, as a systematic effect, the peculiarity of the corresponding portion of the observer's personal scale.

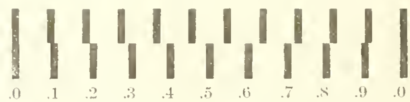
When corrections are to be applied for personal scale the latter should be determined, if possible, from the observations themselves. When these are not sufficiently extensive to furnish a good determination, then the personal scale may be determined (see conclusions 1, 4, and 5 in Part I) from similar estimations made at approximately the same epoch.

(*C*) In designing a measuring scale more than a passing thought should be given to the scale interval to be adopted. Most of us perhaps have at some time or other expressed satisfaction at the attainment of such a high degree of accuracy of measurement that the second settings on good images almost invariably duplicate the first. However, when this condition obtains the measures contain the following two drawbacks: (*a*) the full readily attainable accuracy of the individual measures has not been reached in the readings and, (*b*) the individual results contain the peculiarities of the personal scale of the measurer to nearly their full extent. The remedy lies, of course, in a somewhat finer subdivision of the scales.

So also, I believe, the widths of rulings and of index, which within the ordinary range of experience are best expressed in terms of the scale-interval, are hardly ever given more than a momentary thought. In the discussion above I have merely touched upon the fact that the estimations are influenced to a considerable extent by the widths of the lines. In this direction more work could profitably be done, for a larger number of observers, especially for determining whether there is a range of widths which is most favorable in regard to both the influence upon the personal scale and the ease with which the estimations can be made. For example, in my rather limited tests I found that estimating very wide lines was much more difficult and fatigueing than for narrow lines. This fact was also brought out in the increased range, with wide lines, in the differences "estimated minus measured" and in the larger probable error of a single estimation. Habit and previous experience may have an important influence in this regard.

(*D*) In conclusion I wish merely to offer the suggestion, without making any implication for or against the practical usefulness of the suggestion, that if both rulings and index be given a width of 0.2 of a scale-interval, then the nearest tenth can be accurately read off at a glance instead of being subject to the uncertainties of estimation.[7] Such a scale is illustrated in Fig. 46. For the positions 0.1 and 0.9

Fig. 46



the index and scale ruling overlap each other half way. At 0.2 and 0.8 index and scale division are just tangent to each other. At 0.3 and 0.7 a clear space of one-half a ruling width is between them, which becomes a full width at 0.4 and 0.6. At 0.5 the two sides are balanced. When the index and ruling overlap each other by three-fourths of their widths the position of the index is either 0.05 or 0.95, depending upon the direction. When they overlap by one-fourth of their widths the reading is 0.15 or 0.85. It seems desirable that a number of observers should acquire experience in the use of such a scale in order to learn to what extent its use may be practicable. It may find a limited application in some cases where freedom from the effects of personal scale are especially desired on account of the importance of the individual readings.

August, 1920.

[7] This does not apply to long indices which extend across the entire length of the scale-rulings and in certain positions partly or wholly cover them.

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EVIDENCE OF MOVING CLUSTERS IN KAPTEYN'S FIRST DRIFT.

By AXEL CORLIN.

The following paper gives the preliminary results of an investigation of moving clusters in KAPTEYN'S first drift together with a study of the correlation between spectral type and velocity in this class of moving clusters. The investigation is being continued by the author at the observatory of Upsala and the final results will be published later in a more exhaustive paper.

1. A NEW MOVING CLUSTER OF FAINT STARS.

When studying the distribution in space of ADAMS' and JOY'S[1] 500 stars with spectroscopic parallaxes the writer's attention was attracted to five adjacent stars in right ascension, which were very similar in spectral type, absolute and apparent magnitude (except one), and amount of proper-motion. These five stars are numbers 1, 9, 10, 11 and 12 in Table 1. When the directions of their proper-motions were examined, it was shown that they converged strongly towards a single point, which was approximately determined to be $\alpha = 6^h 12^m$; $\delta = -13°$. The mean deviation (calculated − observed) in position-angle was $\pm 1°.6$, which quantity is smaller than that valid for the hitherto known and examined moving clusters. The possibility was therefore present, that the five stars in reality moved parallel to each other in the direction of the convergent point, and with this assumption I tried to derive their real velocities also. If the velocities proved to be of the same magnitude, it was very probable that the stars moved parallel to each other, and all conditions would be fulfilled for the assumption that they form a part of a moving cluster. These conditions are: convergence towards a single point, equal velocities in the direction of the convergent point, and conformity in spectral type. By the last condition is, however, not meant a limitation to only *one* spectral type, but there must be present more than one star of a given type if we are to assume that this type is represented among the stars of the cluster. (Cf. EDDINGTON: "Stellar Movements" p. 68.)

[1] *Ap. J.*, Vol. 46, p. 313.

The radial velocity is determined for only one of the stars, viz. BRADLEY 3077, and therefore the more uncertain method, not used before, of deriving the real velocity from parallax and proper-motion must be used in this case. This is done by the formula:

$$V = 4.737 \frac{\mu}{\pi \sin \lambda}$$

where V is real velocity; μ is proper-motion; π is parallax; and λ is distance of the star from the convergent point. By differentiating this formula:

$$dV = \frac{V}{\mu} d\mu - \frac{V}{\pi} d\pi - \frac{V}{tg\,\lambda} d\lambda$$

and substituting for $d\mu$, and $d\pi$, and $d\lambda$ the allowable errors in the proper-motion, parallax, and convergent point respectively, and, lastly, summing up all sources of errors, one obtains the allowable error dV for each such determination of velocity. In the calculations here $d\pi$ is assumed to be $\frac{\pi}{10}$ (Cf. STROMBERG: *Ap. J.*, Vol. XLVII p. 15), $d\mu$, 0''.03 (derived by comparison of the proper motions in VAN MAANEN'S and PORTER'S[1] catalogues of the stars employed here), and $d\lambda$, 0.017 (according to the mean error in the determination of the convergent point). The velocities of the five stars, thus derived, with their allowable errors became: 47 ±7.5; 60.5 ±9.9; 66 ±8.0; 53 ±8.6; and 62 ±9.8 km/sec. From the only radial velocity was derived: 62 km/sec. With the exception of the first these velocities do not deviate more from their arithmetical mean (60.3 km/sec) than is permitted by their allowable errors. Therefore it seemed probable that the last four stars in reality belong to

[1] *Cin. Pbl.*, No. 18.

a group which is moving towards: $\alpha = 6^h\ 12^m$; $\delta = -13°$ with a velocity of about 60 km/sec. Perhaps the first star is also a member of the group — the difference in velocity may depend on a greater error in its observed parallax or proper-motion than what is assumed.

A continued examination in this respect of the stars in ADAMS' and JOY's list showed, however, that some more stars in this list ought to belong to the new moving cluster. Further it was probable that ADAMS and JOY had only by chance found some of the members of the cluster, and that there were consequently a greater number of these. For this reason I undertook a systematic search in our catalogues of proper-motion for stars converging to the point mentioned in order to detect possible new members of the cluster. As the members which were already found did not show any pronounced localization on the firmament, the search was extended over the whole sky. For this purpose position-angles for the direction towards the convergent point were calculated from points over the whole sky (a total number of 6700 points, situated at most 4° from each other) and were collected in a table. With the aid of this table the following catalogues were examined for converging stars, the proper-motions of which were $>0''.10$ annually:

1 VAN MAANEN: "List of stars with proper-motion exceeding 0''.50 annually." *Ap. J.*, Vol. XLI, p. 187.

2 INNES: "Proper-motion stars south of −19°." *Union Obs. Circ.*, No. 19.

3 ADAMS and KOHLSCHÜTTER: "The radial velocities of 100 stars with measured parallaxes." *Ap. J.*, Vol. XXXIX, p. 341.

4 KAPTEYN: "Sixth computation of the stars of Bradley." *Gron. Publ.*, No. 9. (Only type II stars.)

5 FURUHJELM: "Recherches sur les mouvements propres des etoiles dans la zone photographique de Helsingfors." *Acta Soc. Scient. Fennicæ*, Vol. XLVIII, No. 1.

Further, parts of the following catalogues were examined:

6 BOSS: "Preliminary General Catalogue."

7 PORTER: "Catalogue of proper-motion stars." *Cin. Publ.*, No. 18, Part I and II.

8 CAMPBELL: "The radial velocities of 915 stars." *Lick Obs. Bull.*, No. 229.

9 ADAMS: "The radial velocities of 500 stars." *Ap. J.*, Vol. XLII, p. 172.

10 KÜSTNER: "Radialgeschwindigkeiten von 227 Sternen." *A. N.*, 4750.

The result was 254 stars converging within 6°; 82 of these showed a proper-motion $\geq 0''.50$ annually. The latter are all the proper-motion stars of this kind known to the year 1915 which converge towards the point, because the lists of VAN MAANEN and INNES complete one another in the publishing of those stars. For 54 of the 82 stars the spectral type was determined, divided according to types in the following manner:

B	: 0	*G*5 to *G*9	: 7
A	: 1	*K*0 to *K*4	: 19
F	: 9	*K*5 to *K*9	: 6
*G*0 to *G*4	: 11	*M*	: 1

In the abrupt raising in number for K0 — *K*4 the new moving cluster seems to show itself.

Among all the 254 stars, of which, however, 125 were $<7^m$ in apparent magnitude, there were 75 with determined radial velocity or spectroscopic parallax. For these stars it was possible to compute their velocities in the direction of the convergent point, and this was also done. Then it appeared that only 12 of the 75 had a velocity that within its allowable margin of error reached or approached 60 km/sec. These stars are shown in Table 1.

It is seen in the table that stars 2, 3, 4, 7, 9, 10, 11 and 12 fulfill all the conditions mentioned above as necessary for the assumption that they belong to a moving cluster. Stars 1 and 6 may be considered as possible members, owing to their pronounced similarities with the other cluster-stars; the disagreement in computed velocity may be due to a greater error in parallax or proper-motion than that which is assumed. The two remaining stars, 5 and 8, on the contrary do not show any resemblance to the cluster-stars or to each other; their velocities to the convergent point, as computed from parallax and proper-motion agree approximately, but as we do not know if these velocities for the two stars are their real velocities and have no reason for assuming it, there is no reason to assume that they belong to the cluster.

The eight safe stars have been employed for a new and more careful determination of the convergent point and of the velocity of the cluster. The convergent point was determined by computing all 28 possible points of intersection for the extended proper-motions of the 8 stars, after which the probable mean of the 22 points which fall in the same part of sky was calculated by means of the method of least square. The probable mean was (with mean error):

$$\left.\begin{array}{l}\alpha = 6^h\ 13^m \ \pm 4^m \\ \delta = -12°.5 \ \pm 0°.6\end{array}\right\} \quad (1900)$$

With these coördinates of the convergent point the real velocities of the 8 stars were calculated again and

TABLE 1

No.	No. Adams and Joy	Name	OBSERVED QUANTITIES									COMPUTED QUANTITIES					
			App. vis. magn.	R. A. 1900	Decl. 1900	Spectrum	Abs. Vis. Magn.	Prop. mot.	Obs. pos. angle	Spect. parallax	Rad. velocity	Dist. from conv. point	Pos. angle		Vel. tow. conv. p.		
													Comp.	Diff	from paral.	dV	from rad. vel.
			M	h m	° ′		M	″	°	″	km/sec	°	°	°	km/sec	km/sec	
1	24	*Lal.* 2682	7.8	1 23.6	+21 13	*K*3	+6.5	0.53	111.2	0.055	....	78.6	109.0	−2.2	47	8.9	..
2	36	*Lal.* 3987	7.8	2 7.5	+67 13	*K*2	+6.0	0.56	122.6	0.011	..	91.1	121.4	−1.2	60.3	10.3	..
3	180	*Man. II* 5178	8.8	10 15.7	0 58	*K*5	+7.8	0.70	255.1	0.063	....	61.5	255.7	0.6	59.9	10.0	..
4	247	*Lal.* 24771	8.3	13 16.1	+43 38	*K*0	+5.1	0.45	264	0.030	..	110.5	268.5	+4.5	75.8	11.8	..
5	254	Boss 3554	6.3	13 12.0	6 51	*F*9	1.7	0.50	254.8	0.048	..	113.4	258.8	−1.0	54	10.1	..
6	271	*Lal.* 27026	7.7	14 46.0	−23 53	*K*5	+6.6	1.02	241.9	0.060	..	117.8	239.9	2.0	91.0	13.5	.
7	313	*Lal.* 29330	8.5	16 1.2	+10 57	*K*0	+7.4	0.50	261.0	0.060	..	118.0	262.7	+2.7	74.4	13.1	.
8	337	*W.B.*16h906	8.8	16 50.1	− 8 9	*Md*	+10	1.27	226.8	0.174		150	223	3.8	69.1	11.1	.
9	475	*Lal.* 45292	7.8	23 1.0	− 2 48	*K*5	+6.6	0.59	102.6	0.018	.	105.9	104.4	1.8	60.5	10.5	.
10	477	*Brad.* 3077	5.6	23 8.5	+56 37	*K*5	+6.6	2.08	82.3	0.158	−20.4	109.6	83.9	1.6	66	8.4	62
11	483	*Lal.* 45638	8.2	23 13.8	+ 4 52	*K*2	+6.6	0.52	103.6	0.018	..	105.3	102.2	−1.1	53	9.7	.
12	484	*W.B.*23h257	8.5	23 15.0	+28 19	*K*1	+6.8	0.57	94.0	0.046	.	109.0	92.9	−1.1	62	11.0	.

assigned weights which stood in an inverse ratio to the squares of the allowable errors; the velocity of Bradley 3077 was assigned a weight of 1. The probable mean of the velocities was 62.4 ±2 km/sec. The single radial velocity gave 61.7 km/sec. As the elements of the apparent motion of the cluster we may therefore take:

$$\left.\begin{aligned} \alpha &= 6^h\ 13^m \\ \delta &= -12^\circ.5 \\ V &= 62\ \text{km/sec.} \end{aligned}\right\}\ (1900)$$

If for the solar motion we assume the values, perhaps a little approximate, $\alpha = 18^h\ 0^m$; $\delta = +30^\circ$; $V = 20$ km/sec, the elements of the "true" motion of the cluster are:

$$\left.\begin{aligned} \alpha &= 6^h\ 18^m \\ \delta &= -4^\circ.5 \\ V &= 43.5\ \text{km/sec.} \end{aligned}\right\}\ (1900)$$

This point is situated at a distance of 14° to 17° from the vertex of KAPTEYN's first drift (according to the places of the vertex given by KAPTEYN[1], EDDINGTON[2], and STRÖMBERG[3]) and in the neighbourhood of the star β *Monocerotis*; accordingly I propose the name: *The β Monocerotis Stream* or in short: *The Monoceros Stream* as a designation for this moving cluster.

With the new elments of the apparent motion of the cluster the computed quantities given in Table 2 were calculated. Table 2 thus shows the characteristics of the *Monoceros Stream.*

The star *Lalande* 45638 or β 80 is a visual double star, the orbit of which is computed by AITKEN. Since its parallax is obtained here it is possible to compute the total mass of the system by using the formula: $m + m_1 = \dfrac{a^3}{\pi^3 P^2}$. The total mass of the system is then found to be 0.6⊙.

As I just remarked, it is not likely that ADAMS and JOY would have included all existing members of the cluster in their list. That nevertheless no new members have been found among the stars for which the radial velocity is determined, is evidently due to the fact that our lists of radial velocities only exceptionally include stars with apparent magnitudes below 6^M, whereas the stars of the cluster seem to be generally of apparent magnitude 7^M to 9^M. On the other hand it was to be expected that members of the cluster would be found among the 116 converging stars with apparent magnitude less than 7^M for which neither the parallax nor the radial velocity, nor in many cases also the spectral type, were determined. But how are we to distinguish them from the other stars? A means of finding at least possible members of the cluster is given with the recently manifested relationship of absolute magnitude to spectral type. If the parallax is computed for a converging star by assuming that the star moves in direction of the convergent point with the velocity of the cluster, and if the absolute magnitude is computed for the star, the absolute magnitude is given in this case as single-valued function of the assumed velocity. If it then appears that the

[1] *M. N.*, Vol. 72, p. 743.
[2] *M. N.*, Vol. 71, p. 4.
[3] *Ap. J.*, Vol. 47, p. 7.

TABLE 2

No. Adams and Joy	Name	OBS. QUAN.		COMPUTED QUANTITIES							
		App. vis. magn.	Spectrum	Dist. from conv. point	Pos. angle		Parallax		Rad. veloc.		Abs. vis. magn.
					Comp.	Diff.	Comp.	Diff. Spectr.	Comp.	Diff.	
		M		°	°	°	″	″	km sec	km sec	M
24	*Lal.* 2682	7.8	*K*3	78.6	108.4	−2.8	0.041	0.014	+12.3	. .	+5.9
36	*Lal.* 3987	7.8	*K*2	91.0	121.0	−1.6	0.043	0.001	− 1.1	. .	+5.9
180	*Mun. II* 5178	8.8	*K*5	61.2	256.2	+1.1	0.061	0.002	+30.1	. .	+7.7
247	*Lal.* 24774	8.3	*K*0	110.0	268.5	+4.5	0.036	0.006	−21.3	. .	+6.1
271	*Lal.* 27026	7.7	*K*5	117.8	239.9	−2.0	0.088	0.028	−29.1	. .	+7.4
313	*Lal.* 29330	8.5	*K*0	147.7	263.4	+2.0	0.071	0.011	−52.7	. .	+7.8
475	*Lal.* 45292	7.8	*K*5	106.2	103.8	+1.2	0.047	0.001	−17.4	. .	+6.6
477	*Brad.* 3077	5.6	*K*5	109.3	83.5	+1.2	0.167	0.009	−20.6	0.2	+6.7
483	*Lal.* 45638	8.2	*K*2	105.5	101.6	−2.0	0.041	0.007	−16.7	. .	+6.3
484	*W.B.* 23ʰ257	8.5	*K*1	108.5	94.7	+0.7	0.046	0.000	−19.8	. .	+6.8
	Mean:	. .	. .	. . .	. . .	° ±1.9	″ 0.064	″ 0.008	. .	. .	M +6.72

absolute magnitude, so computed, agrees with that which is characteristic of the spectral type of the star and of the cluster, then this is a sort of verification of the assumption, and the star may be considered as a possible member of the cluster.

The arithmetical mean of the computed absolute magnitudes of the stars in Table 2 is $+6^{M}.7$, and the magnitudes range from $+5^{M}.9$ to $+7^{M}.8$. If a star is to be considered as possible member of the cluster, according to the argument above, its hypothetically computed absolute magnitude thus must fall within this interval. Now, out of all the 254 converging stars there were 45 — besides the stars in Table 2 — whose spectral type is determined as *K*. Of these, however, only 5 would belong to the cluster, according to the arguments above. On the contrary, of the 74 converging faint stars for which the spectral type is not determined, there were 20 which showed a hypothetically computed absolute magnitude falling within the interval $+5^{M}.9$ to $+7^{M}.8$. Among these 20 stars we may expect to find members of the *Monoceros Stream*; their large proper-motions and low apparent magnitudes suggest the spectral type *K* in most cases. These 25 new possible members of the *Monoceros Stream* are shown with their observed and computed quantities in Table 3.

Finally a few words as to the limitation of the new stream with regard to spectral type and distribution in space. The table — not published in this paper — which contains all the converging stars having either a determined radial velocity or a determined spectroscopic parallax — and from which the 12 stars in Table 1 are collected — favor stars having higher luminosity. Consequently, stars of the spectral types *F* and *G*, if they belong to the stream, would more probably be included in this table than those of spectral type *K*. Since now no such stars have been found there, it is fairly obvious that stars of spectral types *F* and *G* (or in general stars with a higher luminosity than *K*-dwarfs) do not belong to the stream. Nor have any *M*-type stars been found that are to be considered as belonging to the stream. Therefore the *Monoceros Stream* seems to be well limited in spectral type to stars of spectral type *K* alone. — On the other hand, no limitation of the distribution in space of the stream has appeared in the material of converging stars hitherto employed. Therefore the two possibilities remain open, either that the stream is a local system, such as *e. g.*, the *Ursa Major Stream* is known for the present, or that the stream is passing through the whole of KAPTEYN's first drift. The continued investigation of this star stream will perhaps throw some light on this last question.

2. THE 61-*Cygni Stream* REPLACED BY THREE MOVING CLUSTERS?

The strong limitation in spectral type that appeared in the stars of the *Monoceros Stream* has — according to what we have hitherto known — no analogy in a moving cluster, which in other respects is very similar to the *Monoceros Stream*, namely the 61-*Cygni Stream*. This stream shows quite a contrary appearance, as it includes stars of nearly all spectral types. It was,

TABLE 3

No. van Maanen or Innes	Name	OBSERVED QUANTITIES						COMPUTED QUANTITIES					
		App. vis. magn.	R. A. 1900	Decl. 1900	Spectrum	Prop. mot. ann.	Pos. angle	Dist. from conv. point	Pos. angle Comp.	Pos. angle Diff.	Parallax	Rad. vel.	Abs. vis. magn.
		M	h m	° ′		″		°			″	km. sec	M
vM. 33	*Cp.St.St.* 352	9.4	1 2.3	−51 31	*K*	0.50	92.1	72.6	91.6	−0.5	0.040	+18.5	+7.1
vM. 44	*W.B.* 1h356	9.1	1 19.4	+47 59	*K*	0.67	106.0	78.6	107.3	+1.3	0.052	+12.3	+7.7
......	*A.G.Hels.* 2069	8.6	2 11.3	+56 7	*K*0	0.41	120.9	84.9	121.5	+0.6	0.031	+ 5.5	+6.1
vM. 98	*Groom.* 745	8.2	3 48.4	+75 53	*K*	0.64	144.6	91.0	141.8	+0.2	0.049	− 1.1	+6.7
vM. 101	*A.G.Berl.B* 1366	8.9	4 8.6	+22 7	..	0.51	130.9	46.1	135.6	+4.7	0.054	+13.0	+7.6
......	*Furuhj.* 43	9.3	9 5.4	+43 55	..	0.27	220.0	68.7	225.7	+5.7	0.022	+22.5	+6.0
vM. 185	*Lal.* 18397	7.5	9 16.4	+40 38	*K*7*p*	0.55	223.5	67.9	229.0	+5.5	0.045	+23.3	+5.8
.....	*Furuhj.* 290	9.4	10 1.6	+16 31	..	0.26	242	78.0	237.0	−5.0	0.020	+12.9	+6.0
I. 279	....	9.4	10 23.2	−21 11	..	0.31	266.0	60.1	267.4	+1.4	0.027	+30.9	+6.3
	Furuhj. 972	10.5	11 50.6	12 18	..	0.32	255.0	85.7	257.0	+2.0	0.025	+ 4.5	+7.5
vM. 256	*C.P.D.* −37°5339	7.9	12 38.1	−37 9	..	0.69	250.9	87.4	256.2	+5.3	0.053	+ 2.8	+6.5
vM. 264	*W.B.* 12h920	8.5	12 56.2	− 7 54	..	0.54	256.0	98.8	256.0	±0.0	0.042	− 9.5	+6.6
I. 387	....	8.2	12 56.1	−26 50	..	0.52	249	93.8	254.0	+5.0	0.040	− 4.1	+6.2
I. 416	....	8.1	13 27.9	−59 0	..	0.51	246	88.6	247.7	+1.7	0.039	+ 1.5	+6.1
vM. 300	*C.d.C.* +25 12937	9.5	14 23.3	+24 17	..	0.50	273.4	124.6	272.2	−0.9	0.046	−35.2	+7.9
vM. 311	*Lal.* 27155	8.5	14 49.3	+23 45	..	0.75	275.0	130.6	273.6	−1.4	0.076	−40.3	+7.9
I. 564	....	9.0	17 35.8	−40 16	..	0.15	190	126.5	191.3	+1.3	0.043	−36.9	+7.2
I. 578	....	8.1	18 5.1	−43 27	..	0.48	180	123.9	182.4	+2.4	0.044	−34.7	+6.4
vM. 452	*Fed.* 3562	7.2	20 38.7	+75 14	..	0.64	33	114.2	39.4	+6.4	0.054	−25.4	+5.9
I. 649	....	8.7	20 43.2	−20 59	..	0.47	128.7	130.2	128.9	+0.2	0.047	−40.0	+7.1
vM. 466	*Lac.* 8733	7.3	21 10.8	−61 46	..	0.67	131	98.0	136.3	+5.3	0.052	− 8.4	+6.0
vM. 468	*Lal.* 41348	8.5	21 12.9	− 0 15	..	0.44	112.4	133.6	107.5	−4.9	0.046	−42.8	+6.9
vM. 493	*Mun. I* 31343	9.4	22 33.9	+ 2 0	..	0.55	99.5	114.6	102.9	+3.4	0.046	−25.8	+7.8
vM. 514	*A.G.Cam.* 8232	7.0	23 21.0	+52 26	..	1.59	90.6	107.8	92.5	+1.9	0.128	−19.0	+7.6
vM. 527	*B.D.* +45°4378	9.2	23 53.5	+16 10	..	0.53	93.1	102.3	95.2	+1.8	0.041	−13.2	+7.3

however, about ten years ago that this star stream was found and examined by B. Boss[1] and Russell[2], and since that time new determinations of spectral type, radial velocity, and parallax have been made even for stars belonging to the 61-*Cygni Stream*. These new determinations might perhaps change the character of the stream a little, and in order to inquire into this I undertook a comparison between the radial velocities and parallaxes computed by Boss and the new observations for such members of the stream (and also of the less defined stream in the Table V in Boss' second paper) that were received in our latest catalogues of radial velocities and spectroscopic parallaxes. This showed, however, in many cases such great differences that it was evident that a new selection of stars belonging to the stream would have to be carried out and a new computation of the velocity of the stream performed before the true character of the stream could be seen. The new selection was made in the following manner:

All the stars in Boss' and Russell's tables that had determined radial velocities or spectroscopic parallaxes — a total of 41 — were put together in a list, and their velocities towards the convergent point were computed both from the radial velocity and, where possible, from the spectroscopic parallax. Such velocities as were derived by means of the radial velocity for stars lying about 90° from the convergent point were left out of account, because they must be considered illusory. Those stars were then crossed out from the list that proved in reality not to go towards the convergent point owing to reversed sign of the radial velocity or to too great disagreement between the velocity, computed from the radial velocity, and that computed from the spectroscopic parallax. The remaining stars — total 27 — were put

[1] *A. J.*, No. 629, and 633-34.
[2] *A. J.*, No. 635-36.

TABLE 4

No.	No. Boss *P. G. C.*	No. Adams and Joy	Name	Spectrum	Velocity tow. conv. point: from parallax	Velocity tow. conv. point: from rad. vel.	Assumed velocity	Abs. vis. magn.
					km/sec	km/sec	km/sec	M
1	5559	449	24 *Aquarii*	*F*6	33.5	24	..	...
2	3508	...	ζ *Virginis*	*A*2	....	31.3	..	..
3	2161	..	*Pi.* 7 321	*K*5	....	34.4		...
4	3940	298	β *Cor. Bor.*	*F*2*p*	34.3	37.2	.	.
5	5786	462	34 *Pegasi*	*F*5	37	..	.	...
6	3	2–3	*Brad.* 3210^{m}	*G*4	40.1			
7	812	.	κ *Reticulae*	*F*5	...	40.9		
8	.		*Groom.* 884	*F*8	...	42.2		
9	3383	239	ε *Virginis*	*G*6	43	(164)	.	...
10	372	....	*Pi.* 142	*F*8	....	45.1	56.4	+4.3
11	629	..	μ *Ceti*	*A*5	....	52	56.4	+1.5
12	631	.	*Brad.* 390	*F*5	...	53.3	56.4	+2.1
13	3558	255	τ *Bootis*	*F*6	46	58.7	56.4	+2.6
14	1486	...	*Lal.* 2106	*K*	....	58.8	56.4	+3.1
15	...	434	*Groom.* 3357	*F*7	50	59	56.4	+4.3
16	2943	197	51 *Leo Min.*	*F*5	80.4	...	82.5	+4.5
17	1449		π *Mensae*	*G*5	....	82.5	82.5	+4.8
18	...	21	*Lal.* 2450	*G*0	83	..	82.5	+5.7
19	.	500	*Pi.* 23^{h} 267	*G*0	84	..	..	+4.5
20	2657	..	*Lal.* 4059	*K*	....	88.2	{ 82.5 { 101.5	+0.9 +0.5
21	3095		66 *G. Centauri*	*G*	....	98.4	{ 82.5 { 101.5	+4.8 +4.5
22	...	427	*Lal.* 39866	*K*5	98.2	....	101.5	+7.8
23	5433–4	437–8	61 *Cygni*	*K*7	107	100.1	101.5	+8.1
24	1857	....	*Lal.* 2673	*K*2	....	100.2	101.5	+0.5
25	5654	...	ε *Indi*	*K*5	..	107.5	101.5	+6.6
26	5977	478	*Lal.* 45455	*F*4	143	...	....	....
27	927	64	*Lal.* 7443	*K*0	316	...	...	....
1	2	3	4	5	6	7	8	9

together in a new list and were arranged according to the increase in the velocity computed from the radial velocity. This list is shown in Table 4.

As is seen by a glance at the table there appear three well marked groups of velocities in column 7, namely: 52 to 59, 82.5 (80.4 to 84 in column 6) and 98.1 to 107.5 km/sec. Further, each such group seems to be characterized by a special interval of spectral type, namely *F*5 to *F*8, *F*5 to *G*5 and *K*0 to *K*7 respectively. Since the differences of the computed velocities of the stars in each group (the star No. 10 is here included in group 1) is not greater than the allowable errors, some stars in each group fulfill the conditions mentioned above which entitle us to assume that they form a part of a moving cluster. If the arithmetical mean of the velocities of the stars in each group is taken as common velocity, the three clusters obtain the following characteristics:

Cluster	Star's No. Table 4	Vel. Km.	Mean Abs. Mag.
1 *F*-star cluster	10, 12, 13, 15	56.5	$+3^{M}.0$
2 *G*-star cluster	16, 17, 18, 19	82.5	$+4^{M}.9$
3 *K*-star cluster	22, 23, (24), 25	103.0	$+7^{M}.4$ (+5.8)

The question now arises whether the other stars in and around the group also belong to these moving

TABLE 5

Name	OBSERVED QUANTITIES: App. visual magnitude	R. A. 1900	Decl. 1900	Spectrum	Abs. visual magnitude	Prop.-motion annually	Pos. angle	Parallax: Spectr.	Parallax: Trig.	Rad. velocity	COMPUTED QUANTITIES: Dist. from conv. point	Pos. angle: Comp.	Pos. angle: Diff.	Assumed real velocity	Parallax: Comp.	Parallax: Diff. with Spectr.	Parallax: Diff. with Trig.	Rad. velocity: Comp.	Rad. velocity: Diff.	Abs. visual magnitude
CLUSTER 1: THE *F*-TYPE STARS																				
	M	h m	° ′		M	″	°	″	″	km/sec	°	°	°	km/sec	″	″	″	km/sec	km/sec	M
Pi. 142	5.1	1 25.7	+42 7	*F8*	.....	0.82	99.9	...	0.114 ±27	+ 8.6	79.0	99.4	−0.5	56.5	0.070		0.014	+10.8	2.2	+4.3
Brad. 390	4.6	2 40.4	−19 0	*F5*	.....	0.33	82.0	...	....	+25.5	61.4	78.5	−3.5	56.5	0.032			+27.1	1.6	+2.1
τ *Bootis*	4.5	13 42.5	+17 57	*F6*	+3.1	0.49	273.4	0.052	0.042 ±55	−15.4	105.2	275.6	+2.2	56.5	0.043	0.009	0.001	−14.8	0.6	+2.6
Lal. 7507	5.9	17 59.9	−73 41	*F5*	..	0.23	195.8	...	.	...	106.5	190.4	−5.4	56.5	0.020			−16.1		+2.4
Groom. 3357	6.6	20 56.1	+39 51	*F7*	4.6	0.33	47	0.040	0.076 ±35	−37	128.9	48	+1.0	56.5	0.036	0.004	0.040	−35.3	1.7	+4.3
Lal. 8719	5.1	21 6.6	−39 50	*F5*	..	0.23	126.6	...	.....	.....	123.8	133.4	+6.8	56.5	0.023			−31.4		+2.3
Mean:					M +3.8								° ±3.2 [+0.2]		″ 0.037	″ 0.006	″ 0.028		1.5	M +3.0
CLUSTER 2: THE *G*-TYPE STARS																				
Lal. 2450	8.1	1 16.9	+18 10	*G0*	+5.7	0.57	90	0.033	0.012 ±35	...	80.3	93	+3.0	82.5	0.033	0.000	0.021	+13.9	..	+5.7
π *Mensa*	5.7	5 45.1	−80 33	*G5*	.....	1.10	10.9	....	....	+12.2	81.5	12.5	+1.6	82.5	0.064	....		+12.2	0.0	+4.8
51 *Leo Minor*	7.5	10 59.9	+25 45	*F5*	+4.6	0.41	258.7	0.026	0.036 ±51	...	67.9	259.2	+0.5	82.5	0.025	0.001	0.011	+34.1	.	+4.5
66 *G. Centauri*	5.0	11 41.7	−39 57	*G*	.....	1.58	284.3	...	.....	+17.7	79.6	279.5	−4.8	82.5	0.092			+14.9	2.8	+4.8
Pi. 15h 5	7.3	15 7.6	−24 56	*G*	.....	0.40	258.6	....	...		123.7	252.7	−5.9	82.5	0.028	....	....	−45.8	..	+4.5
Pi. 23h 267	6.2	23 59.6	+34 6	*G0*	+4.4	0.78	84.1	0.044	0.007 ±43		97.6	85	+0.9	82.5	0.045	0.001	0.038	−10.9	..	+4.5
Mean:					M +4.9								° ±2.8 [−3.8]		″ 0.048	″ 0.000	″ 0.023		1.1	M +4.8
CLUSTER 3: THE *K*-TYPE STARS																				
Lal. 39866	8.4	20 34.4	+ 4 37	*K5*	+8.0	0.85	86.6	0.083	0.069 ±17	.	150	81	−5.6	103	0.078	0.005	0.009	−89.2		+7.8
61 *Cygni*	5.6	21 2.4	+38 15	*K7*	+7.9	5.18	51.4	0.295	0.292 ± 3	−63	129	49.4	−3.0	103	0.312	0.017	0.020	−64.8	1.8	+8.0
ε *Indi*	4.7	21 55.7	−57 12	*K5*	..	4.71	123.9		0.284 ±40	−38.7	111.1	125.7	+1.8	103	0.231		0.053	−37.1	1.6	+6.5
Mean:					M +7.95								° +3.4 [−6.8]		″ 0.207	″ 0.011	″ 0.027		1.7	M +7.4

clusters. Each star may be considered separately. If star 14 belongs to cluster 1, its absolute magnitude for the velocity 56.5 km sec becomes $+3^M.1$ (column 9) which lies within that range of absolute magnitude where ADAMS and JOY[1] have found scarcely a single star of the type K. If the star belonged to the cluster, it would thus be a very uncommon exception among the stars in general, and, since there are no reasons for such an assumption — especially as there is great possibility that stars appear here which do not in reality move towards the convergent point — the star probably does not belong to the cluster. Star No. 21 may probably belong to cluster 2. Stars 20 and 24 obtain, under the assumption that they belong to cluster 3 (or cluster 2), parallaxes, $0''.012$ and $0''.012$ respectively, which deviate so much from the mean parallax of the cluster — $0''.207$ — that the assumption seems to be improbable. Star 24 would in addition show a difference in computed — observed radial velocity of 10 km sec, which is much too great. Lastly there is star 11. If this star belongs to the cluster 1, its absolute magnitude becomes $+1^M.5$, which according to KAPTEYN[2] is certainly not common for the spectral type $A5$ but which would be found in any case. With the exception of the velocity, the star shows no similarity to any of the cluster-stars, and therefore its possible membership is to be considered very doubtful — the question as to it may, however, be left open. If in addition to these stars two other stars: *Lalande* 7507 and *Lalande* 8519, taken from Boss' Table III in *A. J.*, No. 633–34, are included in cluster 1, and a star: *Pi.* 5 from the same table is included in cluster 2 — for the same reason as the stars in Table 3 were included in the *Monoceros Stream* — the three clusters get the appearance shown in Table 5. With regard to the third cluster it is certainly not correct to assume the existence of a cluster from only three stars. But since the three stars in the K-star cluster show together several features, characteristic for moving clusters of the kind examined here, and since the very low luminosity but probably great dispersion of the stars in a cluster here in question make the stars very difficult to find, we may be allowed to speak of a hypothetical cluster.

As the spectroscopic parallaxes here are not the basis in any case for the computation of the cluster velocities (but only the observed radial velocities) the close agreement between the computed and the observed spectroscopic parallaxes deserves especial attention, as it is not only a means of verifying the adopted velocities of the clusters but also a proof of the great reliability of ADAMS' and JOY'S spectroscopic parallaxes.

The apparent convergent point of the 61-*Cygni Stream* is, according to Boss[1], $\alpha = 6^h\,37^m$; $\delta = +0^\circ.5$ (1875) or $\alpha = 6^h\,39^m$; $\delta = +0^\circ.5$ (1900). But from the mean differences in calculated — observed position-angle in Table 5 it is seen that the three clusters have not an identical apparent convergent point; for the present, however, until more members of the clusters are found, the point $\alpha = 6^h\,39^m$; $\delta = +0^\circ.5$ may be taken to be the apparent convergent point for each cluster. Corrected for the solar motion the true convergent points of the clusters will then be those given in Table 6. For the computation of the galactic coördinates the value: $\alpha = 12^h\,42^m.4$; $\delta = +27^\circ.2$ (1900) is adopted for the pole of the galactic plane.

TABLE 6

Stream	R. A.	Decl.	λ	β	Vel.
	h m	°	°	°	km sec
Monoceros stream	6 18	− 4.5	181.1	−7.5	43
F-star cluster	6 53	+14	168.5	+8.5	40
G-star cluster	6 47	+ 9	172.3	+5.0	66
K-star cluster	6 45	+ 7	173.8	+3.5	86
Mean:	....	.....	173.9	....	..

The true convergent points of the four clusters just mentioned all fall on a slightly curved line at the left side of the vertex for KAPTEYN'S first drift (as determined by the authors mentioned above); their distances from the vertex range from about 8° to about 15°. As the pencil of proper-motion rays to the vertex from stars belonging to the first drift would be of this diameter, the four clusters are very probably in some connection with the great drift. It is seen that the velocity of a cluster is greater the nearer its convergent point is to the galactic plane, which is in agreement with STRÖMBERG'S[2] indication that there is a maximum of space velocity in the galactic plane. The mean galactic longitude of the four clusters is about 90° from the galactic longitude (259° ±6°) that STRÖMBERG has found for the symmetrical plane (perpendicular to the galactic plane) of his velocity-curves.

[1] *Loc. cit.*, p. 331.
[2] *Ap. J.*, Vol. 17, p. 262.

[1] *A. J.*, No. 629, p. 33.
[2] *Ap. J.*, Vol. 47, p. 34.

3 A Correlation between Spectral Type, Absolute Magnitude, and Velocity for the Moving Clusters of the Kind Examined Here.

In the case of the four moving clusters examined here, there has been a pronounced tendency that stars with the same velocity should be only of the same spectral type, and, further, that the higher the velocity of a cluster, the later should be the spectral type of its stars, and the lower their intrinsic luminosity. In order to investigate how the *Ursa Major Stream* and the *Taurus* cluster stand in regard to this relationship I also undertook to examine them in this respect. In the examination of the *Ursa Major Stream* I made use of Bottlinger's[1] investigation into the membership of this star stream. Bottlinger in his discussion allowed for Boss' proper-motions and Campbell's radial velocities. He accepts 16 stars as members of the stream, of which 14 are of the spectral type *A*, 1 of type *F* (37 *Urs. Maj.*), and 1 of type *G5* (ζ *Bootis*). The *G5*-type star, however, is certainly not a member of the stream. Its computed parallax would in that case be 0″.044 but the one spectroscopically observed by Adams and Joy is 0″.145 (and 0″.158 for the second component) and the one trigonometrically observed by Mitchell[2] is 0″.230. Further, its absolute magnitude is for $\pi = 0''.044$: $+3^M.0$, which is quite uncommon for a star of type *G5* on the other hand, $\pi = 0''.15$ gives the standard value $+5^M.7$. Lastly, the disagreement in computed − observed radial velocity is as much as 7.5 km/sec.

If now the criteria for membership of moving clusters is applied to the *F*-type star, this star will be found not to be a member of the *Ursa-Major Stream* either. It shows no similarity to the stars of the stream except an approximate agreement in the direction of the motion and a possible agreement in velocity, but these agreements alone are not sufficient for an assumption that the star belongs to the stream.

The examination of the *Taurus* cluster indicated that this moving cluster is of quite another kind than the preceding moving clusters. The fundamental difference seems to be that the stars in the *Taurus* cluster are concentred within a small part of space — in comparison with their number — and are probably subordinated to the gravitional force from the whole cluster, but in the *Monoceros Stream* or in the *Ursa Major Stream*, for instance, the stars are completely separated from each other and cannot influence one another with their gravitional forces. Within the limits of a moving cluster of the former kind the percentage of stars that do not belong to the cluster is very small; within the moving clusters of the latter kind it is just the opposite. In order to make a distinction between the two kinds in the terminology I here use the name *star-stream* for moving cluster of the latter kind and for those alone — the great star streams of Kapteyn are called drifts.

The examination of the *Taurus* cluster in respect to the correlation between velocity and spectral type showed that no difference in velocity for stars of different spectral types can be shown with probability. As a matter of fact the *F*-type stars show some larger proper-motions than the *A*-type stars, and they have consequently obtained greater parallaxes. If the mean parallax of the *F*-type stars (0″.027) is put equal to the mean parallax of the *A*-stars (0″.025), the former should move 3.3 km/sec more rapidly towards the convergent point, but since that is based on a difference of 0″.002 in parallax it must be considered as illusory. It is perhaps more to be expected that the motions of the stars around a center in the cluster, as indicated by Johnson O'Connor[1], should show a dependence upon spectral type. But no such dependence can be shown in the material available at present.

For the star-streams, however, there seems to be now without exception that *to a given velocity there corresponds always only one strongly limited interval of spectral type.* As, in addition, the velocity seems to be generally greater the later the spectral type is, this fact is in agreement with the correlation between velocity and spectral type which has during the last few years been demonstrated for the stars in common (by Campbell[2], Kapteyn[3], Perrine[4], Strömberg[5], and others). The star streams thus form no exception to this general law for stellar movements in our local stellar system.

Astronomical Observatory, Upsala,
April, 1920

[1] *A. N.*, 4738, (1914).
[2] *Pop. Astr.*, Vol. 25, p. 23.

[1] *A. J.*, No. 669, Vol 28.
[2] *Lick Obs. Bull.*, 196.
[3] *Ap. J.*, Vol. 31, p. 258.
[4] *Ap. J.*, Vol. 42, p. 315 and *ibid.* Vol. 46, p. 266.
[5] *Ap. J.*, Vol. 45, p. 293 and *ibid.* Vol. 47, p. 7.

OBSERVATIONS OF 1920 *G M*,

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY

BY ERNEST CLARE BOWER.

(Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.)

W. M. T.		Apparent Place		⊙ − ★		Comp.	log *pΔ*		App. pl. red. of ★		Seeing	★
	d h m s	h m s	° ′ ″	m s	′ ″				s	″		
Jan.	28 9 5 5	7 48 7.63	+20 51 20.5	+0 2.22	+2 9.2	*d*10 , 8	9.434*n*	0.492	+2.62	−12.3	*p*	1
	29 8 50 27	7 46 59.12	+20 45 0.0	+0 6.85	−0 52.2	*d*10 , 8	9.460*n*	0.502	+2.63	−12.2	*f*	2
Feb.	10 8 45 39	7 34 48.21	+19 27 4.4	+0 18.42	−0 22.7	*d*10 , 8	9.267*n*	0.488	+2.60	−11.8	*p*	4
	13 9 47 1	7 32 18.45	+19 7 15.2	+0 14.03	−2 4.8	*d*10 , 8	8.465*n*	0.471	+2.59	−11.7	*p*	6
	26 9 24 28	7 24 59.23	+17 44 57.2	+0 2.58	−6 26.7	*d*10 , 8	8.665	0.499	+2.43	−11.5	*p*	7
Mar.	2 8 10 26	7 23 40.83	+17 11 57.2	+0 5.71	−3 43.5	*d*10 , 8	8.811*n*	0.510	+2.38	−11.5	*p*	8
	8 9 13 49	7 23 9.71	+16 39 25.3	−0 11.36	+2 9.8	*d*10 , 8	9.067	0.526	+2.26	−11.6	*p*	9
	18 8 21 31	7 24 45.67	+15 13 15.3	+0 3.71	−3 45.7	*d*10 , 8	8.938	0.539	+2.11	−11.7	*f*	10

Jan. 28. Est. 10m. Jan. 29. Est. 10m.2. Feb. 26. Clouds. Moonlight. Mar. 2. Bright moonlight. Mar. 18. Thick haze. Poor observation.

Comp.: *d* = direct micrometer measures.

Mean Places of Comparison Stars for 1920.0

★	α	δ	Authority	
	h m s	° ′ ″		
1	7 48 2.79	+20 49 23.6	Astr. Par. +21.0748	195
2	7 46 19.64	+20 46 4.4	10m, comp. with 3, 1920 Apr. 9. Δα = +0m 6s.07, Δδ = −4′ 15″.0, 1920.0	
3	7 46 13.57	+20 50 19.4	Astr. Par. +21.0748	171
4	7 34 27.19	+19 27 38.9	Comp. with 5, 1920 Apr. 10, Δα = −1m 17s.01, Δδ = −5′ 0″.7, 1920.0	
5	7 35 44.20	+19 32 39.6	*A. G. Berlin A*	2963
6	7 32 1.83	+19 9 31.7	*A. G. Berlin A*	2933
7	7 24 54.22	+17 51 35.4	*Astr. Bor.* +17.0724	110
8	7 23 32.74	+17 11 25.2	*Astr. Bor.* +17.0724	75
9	7 23 18.84	+16 37 27.1	½ { *Astr. Bor.* +17.0724 / *Astr. Bor.* +16.0720	271 / 197
10	7 24 39.85	+15 47 12.7	*Astr. Bor.* +16.0720	538

U. S. Naval Observatory, Washington, D. C.,
1920 May.

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Editor, Benjamin Boss, Dudley Observatory, Albany, N. Y. Associate Editors, E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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VARIATION OF LATITUDE OBSERVATIONS AT U. S. NAVAL OBSERVATORY, 1915.9 – 1920.0,

By F. B. LITTELL.
[Communicated by Rear Admiral J. A. Hoogewerff, U. S. Navy, Superintendent.]

In 1915 the photographic zenith tube devised by Dr. F. E. Ross and used by him at Gaithersburg, Maryland, from June 1911 to October 1914 (see Special Publication No. 27, U. S. Coast and Geodetic Survey) was removed to the U. S. Naval Observatory, Washington, D. C. A new sheet iron louverwork building with removable roof was erected for it and it was installed, and observations were begun with it in October 1915. Since then observations have been made continuously. The observers have been F. B. Littell, G. A. Hill and W. A. Conrad. Nearly all the plates were measured by the writer; a few were measured by Mr. Conrad.

The program consists of 8 groups of 8 stars each, with a few additional stars for scale value, all the stars being within about 10′ of the zenith. The magnitudes of the stars range from 3.0 to 8.5. Screens are used to reduce the magnitudes of the brighter stars. Two groups of stars are on the program for each night following the usual polygon method.

The scale value has been corrected by the results of the observations, and a temperature coefficient has been determined although it was not used in the reductions, its effect being negligible.

The probable error of a latitude from a single star as derived from the residuals from the means on the nights when complete groups were observed was as follows for each year.

Probable Error of One Observation

	No. Obs.	Prob. Error
		″
1916	760	±0.086
1917	640	.093
1918	832	.086
1919	904	.093
Mean		0.089

A few of the nights have residuals that are evidently abnormal. If these nights, four in number, be omitted from consideration the average probable error is ±0″.086. The nights have been weighted according to the number of stars observed as follows: 1 to 4 observations, weight 1; 5 to 8 observations, weight 2; 9 to 12 observations, weight 3; 13 or more observations, weight 4. About three fourths of the nights have a weight of 4.

The results for the separate nights were meaned in overlapping groups, 20 to the year, and a curve was drawn to represent the variation of latitude. The probable error of a latitude for a single night of weight 4, as deduced from the residuals from the plotted curve, is ±0″.030. The probable error of a night of weight 4 deduced from the probable error of a single observation is ±0″.024. Assuming the difference to be due to some kind of error which is persistent for a night but different on different nights, the maximum value to be assigned to the probable error due this source of error is ±0″.018. Some part of this, however, must be assigned to the error of the curve, so that it is probably safe to say that the probable error due to night error does not exceed ±0″.015.

From the closing errors the following values of the aberration constant have been deduced.

	″	
1916	20.440	
1917	20.476	
1918	20.467	
1919	20.413	
Mean	20.454	±0″.008

Washington and Greenwich are favorably situated for determining the motion of the pole and a graphical representation of the path of the pole has been made

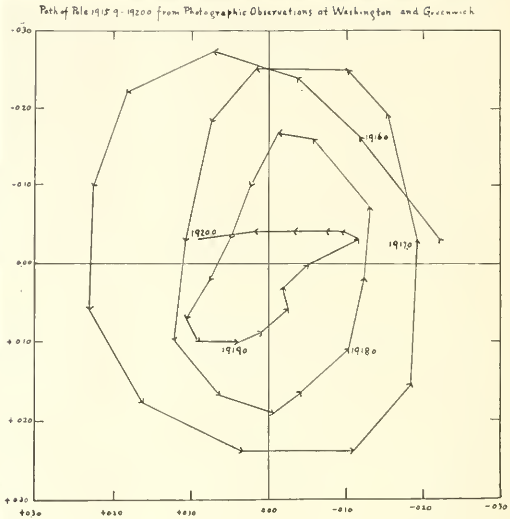
by combining these results with the photographic results obtained at Greenwich for the same period as published in the *Monthly Notices* of the Royal Astronomical Society, Vol. LXXIX, No. 8.

The Kimura or z term has been deduced by deducting the x, y terms as determined by the international variation of latitude service for the years 1916 and 1917, the only ones for which the results were available. The following values of z were obtained, agreeing fairly well in phase and amplitude with the values obtained from the work of the international stations.

Kimura or Z Term

	$''$		$''$
1916.0	+0.05	1917.0	+0.03
.1	+ .03	.1	.00
.2	− .04	.2	− .05
.3	− .05	.3	− .07
.4	− .06	.4	− .10
.5	− .02	.5	− .07
.6	+ .03	.6	− .01
.7	+ .05	.7	+ .01
.8	+ .05	.8	+ .02
.9	+ .05	.9	+ .05
1917.0	+ .03	1918.0	+ .05

The question as to whether there is an anomalous refraction at the zenith due to the formation of an air prism over the place of observation, the effect of which would vary with the direction and intensity of the barometric gradient has been investigated with special reference to the possibility of obtaining an explanation of the z term. The barometric gradient was found from the data on the prediction maps of the U. S. Weather Bureau for each night of observation in 1916 and 1917. By assuming that the deviations of the latitudes for the individual nights from the general curve are due to the barometric gradient a correction of $-0''.0014 \pm 0''.0009$ for a gradient of $+0.0001$ inch per mile has been deduced. By a



slightly different treatment of the observations so as to eliminate the effect of the errors of the curve of comparison, and with the inclusion of some additional material, the value of the correction obtained was $-0''.0008 \pm 0''.0012$ for a gradient of $+0.0001$ inch per mile. As the barometric gradients for the single nights range only from $+0.0008$ to -0.0005 inch per mile, and as the mean gradients corresponding to the mean latitudes used for the formation of the latitude curve range only from $+0.00028$ to $+0.00001$ inch per mile, it is obvious that the correction found above is negligible and is entirely insufficient to account for either the z term or for discordances on single nights.

The following table gives for each observing night the initial of the observer, the number of stars observed, the resulting observed latitude, and the correction to reduce the observed latitude to that given by the adopted curve.

Observed Latitudes of the Photographic Zenith Tube

Date	Obsr.	No. Obs.	Ob'd Lat.	v	Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+					+38° 55′ 16″.00+	
1915			$''$	$''$	1915			$''$	$''$
Oct. 27.5	L	11	0.82	−0.03	Nov. 1.5	L	9	0.78	+0.01
28.5	H	7	.76	+ .03	2.4	H	7	.74	+ .05
29.5	L	9	.74	+ .05	3.5	L	10	.82	− .03
30.5	H	6	.89	− .10	5.5	L	10	.79	.00

Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+	
1915			″	″
Nov. 6.4	H	4	0.78	+0.01
9.5	H	9	.77	+ .02
10.5	L	10	.74	+ .06
11.4	H	4	.78	+ .02
16.4	H	10	.71	+ .09
17.4	L	9	.95	− .15
20.4	H	4	.80	+ .01
24.5	L	5	.68	+ .13
27.6	H	12	.85	− .03
30.5	H	11	.85	− .03
Dec. 6.5	L	13	.83	.00
10.5	L	9	.85	− .01
14.4	H	6	.84	+ .01
15.4	L	6	.83	+ .02
18.4	H	8	1.00	− .14
21.4	H	4	.87	− .01
22.5	L	14	.90	− .04
23.5	H	13	.90	− .03
24.4	L	15	.84	+ .03
27.4	L	9	.88	− .01
1916				
Jan. 3.4	H	10	.98	− .09
7.4	L	13	.82	+ .07
8.4	H	13	.86	+ .03
14.5	L	12	.88	+ .02
20.5	H	12	.92	− .01
25.4	H	6	.95	− .03
Feb. 9.4	L	13	.94	+ .01
10.4	H	4	.98	− .03
27.4	L	12	.94	+ .05
29.4	H	13	.98	+ .01
Mar. 3.4	L	3	1.05	− .05
4.4	H	16	.98	+ .03
5.3	L	10	.94	+ .07
8.4	L	12	1.00	+ .02
9.4	H	6	1.03	− .01
10.5	L	16	1.02	+ .01
11.4	LH	21	1.06	− .03
16.4	LH	19	1.06	− .01
17.5	L	16	1.07	− .02
23.5	H	14	1.02	+ .05
24.5	L	10	1.08	− .01
30.5	H	12	1.16	− .07
31.5	L	14	1.08	+ .02
Apr. 6.4	H	13	1.19	− .07
10.4	L	15	1.08	+ .05
15.4	H	15	1.11	+ .01
17.4	L	15	1.14	+ .01
18.5	LH	19	1.16	.00
			+38° 55′ 16″.00+	
1916			″	″
Apr. 20.6	H	8	01.17	−0.01
23.5	L	16	1.16	+ .01
29.5	H	15	1.22	− .04
30.5	L	16	1.19	− .01
May 3.4	L	6	1.30	− .11
6.5	H	9	1.18	+ .01
7.5	L	16	1.13	+ .06
9.5	H	12	1.14	+ .06
10.5	L	11	1.25	− .05
17.5	L	12	1.17	+ .04
18.4	H	4	1.45	− .23
19.5	L	12	1.24	− .02
26.4	L	6	1.20	+ .03
31.5	L	14	1.23	+ .01
June 1.6	H	16	1.17	+ .07
3.6	H	3	1.28	− .04
5.6	L	16	1.26	− .01
13.5	H	15	1.31	− .05
22.5	H	14	1.28	− .02
23.5	L	16	1.24	+ .02
26.5	H	14	1.26	+ .01
29.5	H	8	1.30	− .03
July 1.5	L	15	1.27	.00
6.5	H	16	1.26	+ .01
7.4	L	7	1.32	− .05
11.5	LH	18	1.27	− .01
12.5	L	20	1.23	+ .03
14.4	L	12	1.23	+ .03
18.4	H	9	1.33	− .07
19.4	L	11	1.29	− .03
20.4	H	9	1.17	+ .08
26.4	L	8	1.23	+ .02
29.5	H	24	1.25	− .01
Aug. 1.4	H	6	1.30	− .06
2.5	L	15	1.20	+ .04
4.5	L	16	1.27	− .03
7.5	L	16	1.24	− .01
8.4	H	5	1.11	+ .12
9.4	L	10	1.24	− .01
10.4	H	4	1.16	+ .07
12.4	H	15	1.19	+ .03
16.5	L	16	1.26	− .05
17.4	H	15	1.26	− .05
18.4	L	7	1.24	− .03
19.4	H	15	1.22	− .02
22.4	H	16	1.21	− .01
24.5	H	16	1.12	+ .07
25.5	L	16	1.16	+ .03

Date	Obsr.	No. Obs.	Ob'd Lat.	v	Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+					+38° 55′ 16″.00+	
1916			″	″	1917			″	″
Aug. 30.5	L	16	1.20	−0.03	Feb. 21.4	L	7	0.75	+0.10
31.5	H	15	1.19	− .03	24.4	H	11	.91	− .06
Sept. 7.5	H	11	1.10	+ .04	26.4	L	6	.84	+ .02
9.5	H	16	1.18	− .05	Mar. 5.4	L	16	.82	+ .05
12.5	L	16	1.16	− .04	6.4	H	15	.93	− .06
16.5	L	16	1.04	+ .06	12.5	L	12	.85	+ .03
19.5	L	16	1.04	+ .05	15.5	H	12	.86	+ .03
23.4	L	16	1.08	.00	17.5	H	12	.98	− .09
25.4	L	16	1.08	− .01	19.5	L	16	.88	+ .02
26.4	H	14	1.09	− .02	22.5	H	13	.88	+ .02
29.4	L	16	1.10	− .05	24.5	H	16	.88	+ .03
Oct. 6.5	L	13	1.02	+ .01	28.4	L	11	.90	+ .02
7.5	H	15	1.06	− .04	29.4	H	4	1.01	− .09
10.5	H	15	1.03	− .02	30.4	L	10	.88	+ .05
11.5	L	16	.97	+ .04	31.5	H	6	1.03	− .10
14.5	H	15	.95	+ .05	Apr. 3.4	H	15	.88	+ .06
20.4	L	3	1.10	− .13	7.4	H	15	.92	+ .03
21.4	H	8	1.00	− .03	9.4	L	15	.87	+ .09
23.5	L	16	.98	− .02	10.4	H	13	1.03	− .07
24.5	H	16	.94	+ .02	11.3	L	2	.95	+ .02
Nov. 1.5	L	16	.92	+ .02	13.4	L	13	1.02	− .05
10.4	L	14	.88	+ .03	18.5	L	4	1.05	− .06
21.4	H	15	.81	+ .08	22.6	L	13	1.02	− .02
Dec. 1.5	L	16	.88	− .01	May 1.5	H	13	1.09	− .07
2.5	H	15	.89	− .02	2.5	L	12	1.10	− .08
6.5	L	16	.81	+ .06	3.4	H	5	.93	+ .10
12.4	H	12	.84	+ .02	9.5	L	13	1.04	.00
13.4	L	3	.68	+ .18	10.4	H	5	1.06	− .02
22.5	L	14	.83	+ .02	11.5	L	6	1.02	+ .02
23.5	H	11	.95	− .10	14.6	L	8	1.20	− .16
26.3	H	3	1.00	− .16	15.5	H	12	1.06	− .02
28.4	H	9	.95	− .11	18.5	L	9	1.04	+ .01
30.4	L	4	.78	+ .06	19.5	H	10	1.02	+ .03
1917 Jan. 6.4	H	15	.87	− .03	23.4	L	13	1.01	+ .04
8.3	L	7	.81	+ .03	24.4	H	5	.92	+ .14
9.3	H	8	.83	+ .01	25.5	L	12	1.10	− .04
11.4	H	16	.78	+ .05	30.4	L	8	.98	+ .08
14.4	L	16	.75	+ .08	June 4.4	L	14	.93	+ .14
16.3	H	9	.87	− .04	7.6	H	12	1.11	− .03
17.4	L	8	.86	− .03	12.5	H	3	1.13	− .04
25.5	H	15	.74	+ .09	13.6	L	13	1.13	− .04
28.5	L	11	.82	+ .01	15.6	L	11	1.09	.00
30.5	L	14	.87	− .04	16.5	H	10	1.15	− .05
Feb. 6.4	H	11	.93	− .09	18.5	L	14	1.10	.00
7.5	L	15	.87	− .03	19.6	H	7	1.16	− .06
9.4	L	14	.75	+ .09	20.5	L	14	1.10	+ .01
14.4	L	9	.86	− .02	22.5	L	3	1.14	− .03
17.4	H	11	.88	− .03	29.5	L	14	1.07	+ .06

Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+	
1917			″	″
June 30.5	H	12	1.15	−0.02
July 6.5	L	14	1.10	+ .04
13.4	H	5	1.26	− .10
23.5	L	24	1.18	− .01
24.5	H	4	1.26	− .09
27.5	L	16	1.23	− .06
28.5	H	15	1.16	+ .02
30.5	L	15	1.20	− .02
31.5	H	15	1.19	− .01
Aug. 1.5	L	16	1.20	− .02
3.5	L	14	1.20	− .02
4.5	H	16	1.22	− .04
7.4	H	4	1.23	− .06
10.5	L	16	1.11	+ .06
13.5	L	15	1.12	+ .05
18.4	H	14	1.22	− .05
22.5	L	8	1.20	− .04
23.4	H	4	1.29	− .13
24.4	L	3	1.14	+ .02
25.6	H	16	1.13	+ .03
27.6	L	16	1.08	+ .08
28.6	H	16	1.16	.00
Sept. 10.5	L	15	1.12	+ .02
12.5	L	16	1.18	− .04
13.5	L	16	1.13	.00
17.5	L	15	1.07	+ .06
18.4	H	7	1.26	− .14
19.5	L	16	1.09	+ .03
20.5	H	10	1.26	− .14
25.4	H	2	1.08	+ .03
26.5	L	14	1.08	+ .03
Oct. 1.4	L	11	1.11	− .01
6.5	H	15	1.08	+ .01
9.5	H	8	.97	+ .12
11.4	H	1	1.09	− .01
12.5	L	8	.88	+ .20
15.5	CL	16	1.07	+ .01
16.5	H	10	1.17	− .10
17.4	CL	17	1.07	+ .01
22.5	C	7	1.01	+ .06
24.5	C	10	1.07	− .01
25.5	H	13	1.06	.00
31.4	C	14	1.06	.00
Nov. 2.4	C	15	1.11	− .05
3.5	H	11	1.05	+ .01
5.4	C	16	.99	+ .06
7.4	C	13	.96	+ .09
8.4	H	15	1.08	− .03

Date	Obsr.	No. Obs	Ob'd Lat.	v
			+38° 55′ 16″.00+	
1917			″	″
Nov. 9.4	C	14	1.19	−0.14
15.4	C	2	1.18	− .14
16.4	C	14	1.02	+ .02
17.4	H	16	1.00	+ .04
19.4	C	4	.91	+ .13
26.5	C	9	1.14	− .12
28.4	C	8	1.13	− .11
Dec. 1.4	H	8	1.09	− .08
2.5	C	9	.98	+ .03
4.4	L	3	.96	+ .05
5.4	C	7	.97	+ .03
6.5	L	11	1.00	.00
10.5	C	13	1.01	− .02
14.5	C	16	1.00	− .01
15.4	L	7	.93	+ .06
20.5	L	16	.98	.00
22.5	L	15	.85	+ .12
26.4	C	12	.97	.00
1918				
Jan. 5.4	L	13	.92	+ .04
8.3	L	4	1.00	− .05
9.4	C	15	1.00	− .05
10.4	H	10	1.06	− .11
12.4	L	16	.91	+ .04
13.4	C	14	.93	+ .02
20.5	C	15	.89	+ .05
22.4	H	8	1.00	− .06
25.5	C	15	.98	− .05
Feb. 4.4	C	6	.93	− .01
9.4	H	5	1.04	− .12
11.4	C	8	.86	+ .06
12.5	H	7	1.00	− .08
13.4	C	10	.80	+ .12
15.4	C	11	.89	+ .02
17.4	L	15	.86	+ .05
18.4	C	7	.92	− .01
20.4	C	15	.87	+ .04
21.4	H	11	.98	− .07
23.4	H	15	.96	− .05
28.4	H	10	.87	+ .03
Mar. 1.4	C	16	.94	− .04
2.4	H	15	.94	− .04
5.5	H	15	.94	− .05
7.5	H	13	.83	+ .06
8.5	C	10	.90	− .01
11.5	C	8	.93	− .04
15.5	C	10	.87	+ .02
16.5	L	6	.86	+ .03
18.5	C	14	.89	.00

Date	Obsr.	No. Obs.	Ob'd Lat.	v	Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+					+38° 55′ 16″.00+	
1918			″	″	1918			″	″
Nov. 23.4	L	6	0.82	+0.07	Aug. 21.4	L	3	1.07	+0.01
25.5	C	16	.87	+ .03	24.5	C	10	1.08	+ .01
26.5	H	16	.98	− .08	29.4	H	3	1.05	+ .04
27.5	L	16	.88	+ .02	Sept. 1.6	C	15	1.16	− .06
28.5	H	15	.86	+ .04	2.6	L	14	1.09	+ .01
Apr. 2.4	H	14	.84	+ .07	4.5	L	16	1.04	+ .06
5.4	C	16	.92	.00	9.5	C	15	1.08	+ .03
15.4	L	14	1.04	− .10	12.5	H	15	1.15	− .04
27.5	H	16	.93	+ .02	13.5	C	12	1.19	− .08
May 1.5	L	15	1.02	− .06	14.5	H	15	1.06	+ .05
2.4	H	5	1.13	− .17	18.5	C	10	1.13	− .01
8.5	L	16	.93	+ .04	21.5	C	13	1.18	− .06
10.6	L	12	.96	+ .01	23.4	C	14	1.07	+ .05
14.5	H	14	.94	+ .03	25.4	C	6	1.13	.00
16.5	H	15	.93	+ .04	27.5	L	15	1.03	+ .10
17.5	L	15	.99	− .02	28.5	C	4	1.22	− .09
22.4	L	4	1.01	− .03	Oct. 2.5	L	6	1.28	− .15
23.5	H	14	.97	+ .01	3.5	H	15	1.10	+ .03
25.5	L	16	.99	− .01	4.5	L	15	1.09	+ .05
31.5	L	13	1.01	− .02	5.5	C	7	1.20	− .06
June 3.5	L	11	1.01	− .02	9.5	L	16	1.08	+ .06
4.6	H	14	.87	+ .12	10.5	H	11	1.12	+ .02
5.6	L	15	.96	+ .03	14.5	L	15	1.14	+ .01
7.6	L	16	1.06	− .06	16.5	L	16	1.19	− .04
9.6	H	16	1.07	− .07	21.5	C	14	1.20	− .04
11.6	H	15	1.06	− .06	22.5	H	15	1.13	+ .03
12.6	L	15	.98	+ .02	Nov. 2.5	C	16	1.20	− .04
13.5	H	4	1.03	− .03	4.4	C	9	1.19	− .03
19.5	L	12	.93	+ .08	5.4	H	10	1.15	+ .01
26.5	L	16	1.04	− .02	8.4	L	13	1.19	− .03
27.5	H	15	1.00	+ .02	13.4	L	15	1.17	− .02
July 1.5	L	16	1.00	+ .03	23.5	C	15	1.10	+ .04
2.5	H	16	1.05	− .02	25.5	C	15	1.19	− .05
8.5	C	15	1.05	− .01	26.5	H	5	1.11	+ .02
13.5	L	16	1.04	.00	27.5	L	11	1.19	− .06
15.5	C	16	1.03	+ .01	30.5	C	16	1.10	+ .03
20.5	C	16	1.03	+ .02	Dec. 5.5	L	9	1.19	− .07
22.5	C	10	1.03	+ .02	17.5	L	15	1.05	+ .06
25.5	H	7	1.08	− .03	18.5	C	16	1.08	+ .03
26.5	L	15	1.08	− .03	19.5	L	16	1.04	+ .06
27.5	C	16	1.07	− .02	26.4	L	15	1.07	+ .03
31.5	L	16	1.05	+ .01	1919 Jan. 6.4	L	16	1.03	+ .06
Aug. 5.5	C	16	1.04	+ .02	7.5	H	4	1.01	+ .08
6.5	H	11	1.10	− .04	9.5	H	15	1.12	− .03
15.5	H	13	1.05	+ .02	10.5	L	16	1.07	+ .02
16.4	L	15	1.06	+ .02	13.5	C	16	1.07	+ .02
19.4	C	14	1.07	+ .01	15.5	L	16	1.12	− .03
20.5	H	4	1.09	− .01	20.4	L	8	1.06	+ .02

Date	Obsr.	No. Obs.	Ob'd Lat.	v	Date	Obsr.	No. Obs.	Ob'd Lat.	v
			+38° 55′ 16″.00+					+38° 55′ 16″.00+	
1919			″	″	1919			″	″
Jan. 24.5	L	16	1.13	−0.05	June 28.5	C	16	0.96	−0.01
26.5	L	16	1.13	− .05	29.5	C	16	.91	+ .01
28.5	H	16	1.16	− .09	July 1.5	H	10	.87	+ .04
31.5	L	16	1.03	+ .04	3.5	C	16	.92	− .01
Feb. 1.5	C	12	1.06	+ .01	4.5	C	15	.90	+ .01
5.5	C	16	1.03	+ .03	8.5	H	14	.85	+ .06
6.5	H	15	1.06	.00	9.4	L	7	.94	− .03
10.5	C	14	1.03	+ .03	11.5	L	16	.92	− .01
19.4	L	15	1.03	+ .01	24.5	H	12	.93	− .01
24.4	C	12	1.06	− .03	25.5	L	15	.90	+ .02
Mar. 1.6	C	12	.95	+ .08	26.5	C	15	.92	.00
3.5	C	8	1.01	+ .02	28.4	C	5	.97	− .05
4.5	H	12	1.03	.00	29.5	H	15	1.01	− .09
11.5	H	15	1.04	− .02	30.4	L	6	.89	+ .03
12.5	L	14	.96	+ .06	Aug. 2.5	C	16	.97	− .05
18.5	H	14	1.05	− .03	6.5	L	12	.90	+ .03
21.5	L	13	1.01	+ .01	7.5	H	7	.92	+ .01
22.4	C	7	1.06	− .04	9.5	C	15	.90	+ .03
24.5	C	16	.97	+ .05	10.5	C	16	.90	+ .03
25.5	H	15	.97	+ .05	11.4	C	8	.94	− .01
28.5	L	10	1.10	− .08	15.5	L	14	.98	− .05
29.5	C	14	1.00	+ .02	18.4	C	5	.84	+ .10
Apr. 2.5	L	16	.99	+ .04	19.4	H	15	.92	+ .02
13.4	C	12	1.13	− .10	20.4	L	15	.95	− .01
18.5	C	12	1.16	− .14	22.6	L	15	.99	− .05
19.6	C	16	1.07	− .05	24.5	C	11	.94	.00
21.6	C	14	1.00	+ .02	25.6	C	15	.95	− .01
26.6	C	16	.96	+ .06	26.6	L	15	.96	− .02
May 2.5	C	14	1.03	− .01	28.5	H	5	.93	+ .01
3.5	L	10	1.02	− .01	Sept. 2.5	H	12	.91	+ .01
17.4	C	7	.95	+ .05	3.6	L	16	.97	− .02
18.5	L	15	1.00	− .01	5.5	L	11	1.00	− .05
19.4	C	5	1.13	− .14	8.5	L	16	.85	+ .10
23.5	L	13	1.05	− .07	12.5	L	16	1.01	− .06
26.5	C	15	.89	+ .09	18.5	H	16	.95	.00
27.4	H	2	1.06	− .09	24.4	L	16	.92	+ .04
28.5	C	8	.96	+ .01	25.4	H	10	.85	+ .11
29.5	H	12	.98	− .01	26.4	L	16	.97	− .01
30.5	L	11	1.04	− .07	27.6	C	16	.91	+ .05
31.4	C	3	1.09	− .12	Oct. 3.5	L	16	1.07	− .10
June 2.5	C	14	.91	+ .05	4.5	C	6	1.02	− .05
3.5	H	12	.98	− .02	6.5	L	15	.97	.00
6.6	L	13	.91	+ .04	7.5	H	14	1.01	− .04
7.5	C	12	.94	+ .01	18.5	H	15	.92	+ .07
16.5	C	4	.93	.00	27.4	L	8	1.04	− .04
17.5	H	14	.98	− .05	28.5	H	15	1.00	.00
19.5	H	10	.87	+ .06	Nov. 2.5	L	15	1.01	.00
22.5	C	16	.92	.00	6.4	H	15	.97	+ .05

Date		Obsr.	No. Obs.	Ob'd Lat.	
				+38° 55′ 16″.00+	
				″	″
Nov.	9.4	L	12	1.27	−0.25
	13.4	H	16	1.03	.00
	15.4	L	16	.95	+ .08
	18.4	L	7	1.12	− .09
	22.5	H	9	1.11	− .07
	24.5	L	16	1.02	+ .03
Dec.	1.5	L	16	.99	+ .07
	3.5	L	16	.92	+ .15
	4.5	H	16	1.08	− .01
	10.5	L	16	1.08	.00
	15.5	L	16	1.10	.00
	17.5	L	14	1.10	.00
	20.4	H	11	1.12	− .01
	21.5	L	14	1.08	+ .03
	30.4	H	10	1.16	− .03

The following table gives the variation of latitude for each twentieth of a year as deduced from the latitude curve. The mean latitude used is the mean of the latitudes for the four years 1916.0 — 1920.0.

Corrections to Mean Latitude for Washington

	1915	1916	1917	1918	1919
	″	″	″	″	″
.00	. . .	−0.15	−0.19	−0.07	+0.06
.05	. . . .	− .12	− .20	− .09	+ .05
.10	.	− .09	− .19	− .11	+ .03
.15	. .	− .05	− .18	− .13	+ .01
.20	. .	+ .01	− .15	− .14	− .01
.25	. .	+ .07	− .10	− .12	− .01
.30		+ .13	− .04	− .09	− .01
.35		+ .16	.00	− .07	− .02
.40	.	+ .20	+ .03	− .05	− .05
.45		+ .23	+ .06	− .03	− .09
.50		+ .24	+ .10	.00	− .12
.55		+ .23	+ .13	+ .02	− .11
.60		+ .20	+ .14	+ .04	− .10
.65		+ .16	+ .13	+ .06	− .09
.70		+ .09	+ .10	+ .08	− .08
.75	. .	+ .02	+ .07	+ .10	− .06
.80	. .	− .05	+ .04	+ .12	− .04
.85	−0.24	− .10	+ .02	+ .12	− .01
.90	− .22	− .14	.00	+ .11	+ .01
.95	− .18	− .17	− .04	+ .08	+ .05

THE PARALLAX OF α *ORIONIS*, ($5^h 50^m$, $+7° 23′$),

By FRANK SCHLESINGER.

In view of Professor Michelson's recent success in measuring the angular diameter of this star (*Betelgeuse*), the following determination of the parallax will be of interest. Fourteen plates, each with three images, were obtained with the Thaw Refractor of the Allegheny Observatory, in six seasons, between October 1914 and October 1917. The first seven of the plates were measured by Mr. Hudson, the last seven by Miss Knudsen. They yield for the relative parallax and its probable error:

+″.013 ±″.007

The only other published determination is by Elkin, with the Yale Heliometer: +″.024 ±″.024. A determination by Adams and Joy by the spectroscopic method is in press: +″.012 (absolute). Combining these after correcting the trigonometric determinations for the probable parallaxes of the comparison stars, we obtain the mean, +″.014. If then the angular diameter of the star is 0″.04, the linear diameter, according to this mean parallax, is nearly three times the radius of the earth's orbit, or about 260,000,000 miles.

Yale Observatory,
January 10, 1921.

OBSERVATION OF THE PARTIAL ECLIPSE OF THE *SUN*, NOV. 9, 1920.

The observations were made with the 10½ in. equatorial by F. P. Leavenworth and with the 4 in. equatorial by Wm. O. Beal.

The limb of the *Sun* was "boiling" considerably at the time of First Contact; less so at the time of Last Contact.

Time of First Contact	10½ in.	1^h	51^m	29^s	G. M. T.
Time of Last Contact	10½ in.	3	36	23	G. M. T.
Time of First Contact	4 in.	1	51	44	G. M. T.
Time of Last Contact	4 in.	3	36	10	G. M. T.

University of Minnesota, Minneapolis,
Dec. 8, 1920.

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OBSERVATIONS OF COMET *TEMPEL II*,

WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

G. M. T.	App. α	App. δ	☄ − ★		Comp.	Log pρ		Ap. pl. rel of ★		Seeing	★
1920	h m s	° ′ ″	s	′ ″				s	″		
Jul. 26.83904	2 7 14.56	− 1 32 51.9	− 13.06	−2 59.6	d10, 8	9.487n	0.751	+2.50	+15.2	*p*	1
Sep. 13.80720	3 2 15.09	− 7 54 4.6	+ 16.75	−2 50.0	d10, 8	9.179n	0.802	+3.41	+18.4	*f*	2
14.80174	3 2 9.95	− 8 4 21.8	−105.22	+3 52.7	t50, 10	9.199n	0.803	+3.41	+18.3	*vp*	4
17.81646	3 1 35.97	− 8 35 21.6	+ 16.20	−0 31.9	d10, 8	8.968n	0.809	+3.48	+18.5	*f*	6
Oct. 9.82721	2 46 6.62	−11 39 51.5	− 11.58	+7 13.8	d10, 8	9.156	0.827	+3.91	+19.2	*p*	7
Nov. 4.68255	2 17 37.23	−11 59 6.4	+ 42.60	−1 0.3	d10, 8	8.121n	0.833	+4.21	+18.0	*p*	9

Jul. 26. Brightness 10^m. Clouds. Sept. 13. Faint. Haze. Poor observation. Sept. 14. Very poor observation. Oct. 9. Faint. Haze. Very poor observation. Nov. 4. Very faint and diffuse. Haze. Very poor observation. Used step star $12\frac{1}{2}^m$.

Comp.: *d* = direct measures; *t* = transits.

Mean Places of Comparison Stars for 1920.0

★	α	δ	Authority
	h m s	° ′ ″	
1	2 7 25.12	− 1 30 7.5	½ { *Astr. Alg.* −2.0208,14 / *Astr. Alg.* −1.0204,95 }
2	3 1 54.93	− 7 51 33.0	{ 11^m, comp. with 3, 1920, Sept. 13, $\Delta\alpha = +1^m\,34^s.30$, $\Delta\delta = +3'\,13''.9$, 1920.0 }
3	3 0 20.63	− 7 54 46.9	*P. G. C.* Boss 700
4	3 3 51.76	− 8 8 32.8	{ *B. D.* −8.587 comp. with 5, 1920 Sept. 17, $\Delta\alpha = +10^s.43$, $\Delta\delta = -7'\,10''.1$, 1920.0 }
5	3 3 41.33	− 8 1 22.7	*A. G. Wien-Ottakring* 710
6	3 1 16.29	− 8 35 8.2	*A. G. Wien-Ottakring* 699
7	2 46 14.29	−11 47 54.5	{ $12\frac{1}{2}^m$, comp. with 8, 1920, Oct. 14, $\Delta\alpha = -17^s.07$, $\Delta\delta = +3'\,44''.3$, 1920.0 }
8	2 46 31.36	−11 51 38.8	*A. G. Camb. U. S.* 648
9	2 16 50.42	−11 58 24.1	*A. G. Camb. U. S.* 525

U. S. Naval Observatory, Washington, D. C.,
1920, Dec. 1.

A PROPOS DE LA PARALLAXE DE *NOVA AQUILÆ* NO. 3,

PAR H. PHILIPPOT.

Dans le No. 773 de l'*Astronomical Journal*, M. F. HENROTEAU publie les résultats d'un calcul de la parallaxe de *Nova Aquilæ* No. 3, qu'il a refait d'après mes observations. Comme il semble dire à ce propos que j'ai inconsciemment fait abstraction du mouvement propre, je tiens à faire ici quelques remarques.

Tout d'abord M. HENROTEAU n'utilise qu'une partie de mes observations et il arrive à un résultat tout différent du mien, ce qui n'a rien d'étonnant. Il attribue ensuite arbitrairement des poids selon la qualité de l'image; j'ai au contraire donné le même poids à toutes mes observations parce que l'appréciation de la qualité de l'image n'est que le résultat d'une impression au moment de l'observation; la précision ne s'en ressent pas toujours d'après ce que j'ai constaté au cours des réductions de mes observations méridiennes.

Il introduit en outre le mouvement propre comme une inconnue du problème, ce qui est le cas général dans des recherches de ce genre. Mais lorsque ce mouvement propre peut être déterminé par des observations très distantes l'une de l'autre, il est évident qu'on peut procéder autrement. Je ferai remarquer d'abord qu'il ne s'agit ici que du *mouvement propre en ascension droite* et non du mouvement propre total et qu'on ne peut pas à priori affirmer que le mouvement propre en ascension droite est du même ordre de grandeur que la parallaxe annuelle. Le mouvement propre total et la parallaxe peuvent être relativement grands tandis que le mouvement propre en ascension droite peut être petit ou nul; celà dépend de la direction du mouvement.

Je n'ai pas considéré le mouvement propre en ascension droite comme une inconnue; voici pourquoi. J'avais lu dans *A. N.* No. 4949, p. 71, que d'après deux positions photographiques obtenues à Alger en 1892 et 1895, M. COURVOISIER concluait à un mouvement propre annuel de $+0^s.0016$. Comme mes observations ne s'étendent que sur un intervalle de 107 jours, celà correspond à un déplacement en ascension droite de $0^s.00048$ de la première à la dernière observation. J'ai estimé que ce mouvement propre, déterminé à l'aide d'un intervalle de près de 25 ans, était bien plus précis que celui qu'auraient pu donner mes observations sur un intervalle de 107 jours. Vu la petitesse de l'effet de ce mouvement propre, je l'ai négligé et non pas ignoré (voir mon travail p. 40). Si je n'ai point cite les *A. N.*, c'est que nous étions encore à ce moment en 1918. Tout au plus aurais-je dû apporter aux ascensions droites observées une correction qui pour la dernière n'aurait pas atteint $0^s.0005$. Faut-il regretter de ne pas l'avoir fait? Au surplus il y a lieu d'ajouter que les mouvements propres en ascension droite des étoiles de comparaison sont eux-mêmes forcément négligés; c'est pourquoi j'ai soin de ne parler que le *parallaxe relative*. M. HENROTEAU arrive à un mouvement propre de $-0''.41$ pour 100 jours, soit un mouvement annuel de $-1''.50$, valeur tout à fait illusoire et qui ne correspond pas du tout à la valeur indiquée ci-dessus et provenant d'un procédé autrement précis.

La parallaxe que j'obtiens est évidemment un résultat de calcul; je n'ai jamais pensé autrement et le dis en d'autres termes dans l'opuscule (voir p. 43). Voici cette phrase "Nous pouvons finalement conclure que la valeur de la parallaxe de la *Nova Aquilæ résultant des observations qui précédent* est de $\pi = +0''.20\ldots.$" Les observations sont du reste trop peu nombreuses et s'étendent sur un trop faible intervalle de temps pouv donner un résultat offrant quelque certitude. L'astre ne s'y prête. du reste pas, à cause de sa position. Je considère donc le nombre obtenu comme une limite supérieure.

D'un autre côté, la combinaison de mes observations avec les données photographiques d'Alger, donne un mouvement propre total de $0''.039$ environ. Si l'on admet que la parallaxe annuelle soit en moyenne la sixième partie du mouvement propre total, il faut en conclure que celle de la *Nova Aquilæ* est inférieure à $0''.01$. Les observations méridiennes sont trop peu précises pour déceler une pareille quantité avec plus ou moins de certitude. Elles doivent céder le pas à la méthode photographique qui est incomparablement plus précise et moins laborieuse.

Enfin je rappellerai que les observations du début, alors que l'éclat de l'astre était très grand, ont été faites à l'aide d'écrans placés devant l'objectif (voir mon travail p. 28) et qu'il n'y a guère de raison de les croire moins bonnes que les dernières.

L'expression du facteur parallactique P que donne M. HENROTEAU est indépendante de la déclinaison; c'est une erreur. Elle doit être multiplieé par le facteur *séc.* δ, qui, dans le cas actuel, est voisin de l'unité mais qui, dans une formule générale, ne peut être supprimé.

Observatoire d'Uccle,
Octobre, 1920

PARTIAL ECLIPSE OF THE *SUN*, NOVEMBER 10, 1920,

OBSERVED AT THE U. S. NAVAL OBSERVATORY, WASHINGTON, D. C.

By ELEANOR A. LAMSON.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent]

The results of the visual observations of first and last contact made at the U. S. Naval Observatory are as follows:

Observer	First Contact G. M. T.	Last Contact G. M. T.	Instrument
	h m s	h m s	
HALL	2 0 22	4 9 5	12-inch equatorial
HAMMOND	2 0 20	4 8 59	5-inch equatorial
HILL	2 0 19	4 8 56	5-inch equatorial
BURTON	[2 0 29]*	4 9 9	5-inch equatorial
BOWER	. . . . . .	4 9 7	5-inch equatorial
	h m s	h m s	
Mean	2 0 20	4 9 3	

*Noted as poor by observer.

Computed times of contract { First $2^h\ 0^m\ 22^s$; Last 4 9 31

Several photographs of the eclipse were also made near the time of last contact with the 40-foot photoheliograph by G. H. PETERS assisted by C. B. WATTS, the sidereal time being carefully noted at the instant of each exposure. To determine the instant the *Moon* moved off the *Sun's* disc, *i. e.*, the time of last contact, the following scheme was used, based upon suggestions made by A. NEWTON of the *Nautical Almanac Office*.

The geocentric right ascension and declination of the *Sun* and *Moon* were computed for three times, two minutes apart, grouped about the approximate time of second contact based upon the elements of the eclipse found in the *American Ephemeris*, 1920. These positions were reduced to Washington and the distance between the centers of the two bodies computed, from which one obtained the rate per second of the increase of the line of centers as the *Moon* moved off the *Sun's* disc.

The length of the common chord on the photographic plate was measured for each partial phase and reduced to arc. The distance between centers was then obtained by solving the triangles comprised between the radii, the semi-chord and the line of centers. Having the rate of change of line of centers, as mentioned in the preceding paragraph, it is easy to compute the instant when the two bodies are in contact for each exposure. The following results were obtained for last contact based on these plate measures.

Plate	Observed Time of Exposure G. M. T.	Length of Chord	Time of Last Contact G. M. T.
	h m s	"	h m s
I	4 6 52.9	336.0	4 9 17
II	4 7 23.8	299.4	4 9 18
III	4 7 53.8	[234.3]*	[4 9 4]
IV	4 8 27.8	213.3	4 9 26
V	4 9 1.9	[73.4]†	[4 9 9]
			h m s
		Mean	4 9 20

*Distortion on plate. †Questionable on plate.

PROPER-MOTIONS OF CERTAIN LONG PERIOD VARIABLE STARS,

By ANNE S. YOUNG and LOUISE F. JENKINS.

PLATES

A series of photographs of the fields around faint variable stars was made with the 24-inch reflector of the Yerkes Observatory by MR. PARKHURST and MR. JORDAN during the years 1902 — 1908. In every case the image of the variable was at or near the center of the plate, and although such reflector plates might not be well adapted to a general study of proper-motions, yet because of their favorable position on the plates it seemed worth while to attempt to determine the proper-motions of some of these variables. Plates selected from this series were therefore duplicated for us at the Yerkes Observatory under the direction of MR. PARKHURST, the hour-angle, aperture, and exposure time of the second plate corresponding to that of the first, and the magnitude of the variable being as nearly the same as possible upon the two plates. The usual length of exposure was one hour,

the aperture used was 18 inches unless otherwise noted. The scale of the plates is 87″.38 to the millimeter.

Measures

These plates were measured at Mount Holyoke College in a Gaertner machine which has two screws at right angles to each other. The pitch of both screws is 0.5^{mm} to a revolution; one division of the screw heads corresponds to 0.001^{mm}.

For each field a set of standard stars was selected, usually within 8′ of the center, and so distributed that the sums of the x and y coördinates were very nearly zero. As each pair of plates was examined in the stereocomparator at the Yerkes Observatory before it was sent to us, no star of large proper-motion was included among these standards. The balancing of distances made least squares solutions unnecessary and simplified greatly the reduction of the measures.

The early plate was oriented in the machine by *A. G.* stars or by the mean of star trails, weighted according to their distance from the center. The second plate was oriented to correspond to the first. Each plate was measured in both direct and reversed positions, and each pair of plates was measured and reduced independently by each observer. The average probable error of a single setting, determined from measures of three plates, was ±0″.074 in x, ±0″.093 in y.

Results

Results are given in the tables which follow. The plates for the stars in Table 1 were considered good and at a later time the measures of these will be published so that they may be available for use in the determining of more accurate proper-motions in the future. Proper-motions for stars in Table 2 were for various reasons considered less reliable and these measures will probably not be published. The columns of these tables contain the designation of the star, the right ascension and declination as given by Graff[1], the date of the early plate, the number of years in the interval between the two plates, the number of standard stars, the mean of the two determinations of the annual proper-motions in right ascension and declination, and the residuals in units of 0″.001. In right ascension the proper-motion is given in both arc and time.

The probable errors of the annual proper-motions found were computed for several plates from least squares solutions and ranged from ±0″.003 to ±0″.005.

For two of the stars in Table 1 proper-motions

[1] Ortsverzeichnis von 580 Veränd. Sternen, *Astron. Abhand.* der Hamburger Sternwarte in Bergedorf, Bd. 1, Nr. 3.

Table 1

Star	R. A. (1900)	Decl. (1900)	Ep.	Int.	No. Stars	μ_α		μ_δ	Resid. in α	Resid. in δ
	h m s	° ′ ″		y		″	s	″		
RR Andromedæ	0 45 56.86	+33 49 58.3	07.85	9.21	21	+.030	.0024	−.052	1	5
Y Andromedæ	1 33 45.16	+38 50 7.4	07.85	11.24	24	−.019	.0016	+.009	2	1
T Camelop.	4 30 20.77	+65 56 44.4	07.87	11.26	29	+.011	.0018	−.011	4	0
V Orionis	5 0 47.02	+ 3 57 59.5	07.76	11.32	20	+.018	.0012	+.022	1	0
Y Monoc.	6 51 19.04	+11 22 22.2	08.24	8.98	20	−.019	.0013	−.024	1	1
**R Geminorum*	7 1 20.12	+22 51 28.2	05.00	14.15	28	−.021	.0015	+.006	1	4
T Geminorum	7 43 18.04	+23 59 0.6	08.24	10.03	25	+.023	.0017	−.017	7	3
U Cancri	8 30 2.70	+19 14 25.8	08.24	10.02	22	+.019	.0013	−.001	8	3
S Hydræ	8 48 21.17	+ 3 26 46.2	08.31	8.98	25	−.024	.0016	+.028	7	2
T Hydræ	8 50 47.94	− 8 45 35.1	08.26	9.99	25	−.021	.0014	+.001	7	1
T Virginis	12 9 28.80	− 5 28 47.8	08.02	10.19	19	−.006	.0004	−.009	6	2
S Sagittarii	19 13 34.85	−19 12 21.1	07.61	12.03	26	−.006	.0004	−.012	6	8
*χ *Cygni*	19 46 43.44	+32 39 40.6	04.54	15.11	37	−.017	.0014	−.034	5	6
Z Cygni	19 58 37.47	+49 45 51.5	07.49	12.00	31	−.002	.0002	−.018	8	0
W Capricorni	20 8 36.26	−22 16 51.0	07.73	11.94	22	+.001	.0001	−.027	5	1
T Delphini	20 40 43.27	+16 2 6.2	07.81	9.81	22	+.000	.0000	+.023	5	6
RR Aquarii	21 9 49.10	− 3 18 37.0	07.66	12.00	19	+.022	.0014	+.047	10	7

*Aperture 12 inches.

Table 2

Star	R. A. (1900)	Decl. (1900)	Ep.	Int.	No. Stars	μ_α	μ_δ	Resid. in α	Resid. in δ
	h m s	° ′ ″		y		″ s	″		
S Arietis	1 59 15.42	+12 2 51.3	07.86	9.21	17	−.089 .0060	−.019	2	1
R Ceti	2 20 55.44	− 0 37 47.0	07.90	11.98	21	−.013 .0009	+.018	6	3
V Geminorum	7 17 32.72	+13 17 34.0	08.30	8.98	23	−.022 .0016	−.033	7	10
RU Herculis	16 6 2.74	+25 19 55.6	04.44	15.05	16	+.004 .0003	−.005	1	9
S Scorpii	16 11 42.65	−22 38 46.6	08.26	10.24	22	−.030 .0022	+.021	10	6
W Ophiuchi	16 16 1.11	− 7 27 42.6	07.51	12.03	22	+.023 .0015	+.020	15	1
†*RS Herculis*	17 17 30.86	+23 1 6.2	07.59	10.04	14	−.002 .0002	+.042	4	3
SY Cygni	19 42 13.54	+32 27 33.5	07.59	12.29	29	−.012 .0010	+.028	12	9
Z Aquilæ	20 9 51.41	− 6 27 20.5	07.46	12.12	23	+.022 .0015	−.006	6	3
S Pegasi	23 15 29.05	+ 8 22 19.6	07.82	11.83	14	−.055 .0037	−.036	8	3

†Measured by Miss Farnsworth instead of Miss Jenkins.

Table 3

Star	Field	Mag.	R. A. (1900)	Decl. (1900)	Ep.	Int.	μ_α	μ_δ
		M	h m s	° ′ ″		y	″ s	″
*.	*W Androm.*	14	2 9 53.3	+43 36 2	02.03	15.75	+.05 .005	−.22
*.	*W Androm.*	13	2 11 49.1	+43 47 40	02.03	15.01	+.46 .042	−.10
*Hagen 46	*W Androm.*	11.8	2 10 43.2	+43 52 44	02.03	15.01	−.02 .002	−.12
Hagen 34	*V Orionis*	12.1	5 0 44.7	+ 4 11 55	07.76	11.32	+.40 .027	+.12
B.D. +31° 3767	*SY Cygni*	9.2	19 42 27.8	+31 46 54	07.59	12.30	+.45 .036	−.42
**B.D.* + 8° 5037	*S Pegasi*	8.7	23 12 55.3	+ 8 31 55	07.82	11.83	+.42 .028	−.11
*.	*U Puppis*	14.5	7 57 51.2	−12 48 23	08.26	11.88	+.20 .014	−.36

*Miss Young's measures.

have already been published as follows: —

Star	μ_α	μ_δ	Authority
	s	″	
R Geminorum	−0.008	+0.04	*A. G. Berlin A*, p. 224
χ *Cygni*	−0.0060	−0.054	Boss, *Prelim. Gen. Cat.*
	−0.001	−0.04	Tucker, *Lick Obs. Bull.* No. 323.

Our results for χ *Cygni* are in good agreement with Professor Tucker's values based upon the 1900 position in the *Preliminary General Catalogue* and a meridian circle observation made at the Lick Observatory in 1919.

Table 3 gives similar data for seven stars whose proper-motions are so large as to be evident in the stereocomparator, and are the only ones found in the examination of 60 fields. Images of these stars, because of their distance from the center of the plate, were elongated and sometimes even cometary, so that the positions given, computed from the measures, are for identification only. The proper-motions were determined by a comparison with a group of neighboring stars whose images were of similar shape, so that the percentage of error in these is probably small.

The last star on the list, *B. D.* +8° 5037, is No. 11591 of the *A. G.* Zone 5° — 8°.

In conclusion we wish to express our thanks to Dr. Alice Farnsworth, who took most of the plates of the second series, and to Professors Parkhurst and Frost of the Yerkes Observatory for their many helpful suggestions as well as for their kindness in loaning the plates used in this investigation.

Mount Holyoke College,

November, 1920.

THE PARALLAXES OF THIRTY-FOUR STARS,

By FRANCES ALLEN and FRANK SCHLESINGER.

For this series of parallaxes the average probable error is 0″.0080, the average number of plates 14.7, and the average number of comparison stars 3.8. All the measurements were made by Miss Allen. The details of these determinations will, as usual, appear in the *Publications of the Allegheny Observatory*.

No.	Name	α (1900)	δ (1900)	Durchmusterung Number	Visual Magn. and Spectrum	Total Proper-Motion	Relative Parallax and Probable Error		Probable Error for One Good Plate
		h m	° ′	°		″	″	″	″
366	22 *Andromedæ*	0 5	+45 31	+45 17	5.1 F0	.007	**−.009**	**±.010**	±.025
367	*Lalande* 617	23	+ 9 39	+ 9 47	6.0 F2	.21	**+.029**	**7**	21
368	*φ Piscium*	1 8	+24 3	+23 158	4.6 K0	.05	**−.010**	**8**	23
369	*ω Andromedæ*	22	+44 53	+44 307	5.0 F5	.36	**+.024**	**4**	13
370	*Piazzi* 145	36	+25 14	+25 276	6.3 F5	.14	**+.005**	**9**	22
371	*Lalande* 4268	2 13	+ 1 17	+ 1 410	5.8 F8	.53	**+.043**	**10**	25
372	*Lalande* 5376	50	+26 28	+26 484	7.4 G5	.33	**+.056**	**7**	20
373	*Mayer* 120	3 28	+17 30	+17 575	6.4 K0	.33	**+.021**	**8**	23
374	*Lalande* 7036	46	+60 53	+60 762	7.8 K0	.48	**+.018**	**8**	20
375	OΣ 531	4 1	+37 49	+37 878	7.1 G5	.29	**+.026**	**7**	22
376	49 *Persei*	2	+37 28	+37 881	6.2 G5	.21	**+.019**	**7**	21
377	*Lalande* 8248	20	+46 38	+46 884	6.7 G0	.32	**+.022**	**9**	26
378	*Bradley* 671	53	+66 41	+66 370	6.3 F8	.35	**+.030**	**6**	18
379	*Piazzi* 294	5 3	+46 50	+46 970	5.6 F5	.17	**+.024**	**5**	13
380	*Lalande* 11499	59	+14 24	+14 1136	6.7 F5	.21	**+.004**	**8**	22
381	*Lalande* 11774	6 7	+ 6 49	+ 6 1155	7.1 G0	.31	**+.017**	**8**	20
382	*Lalande* 13942	7 8	+47 25	+47 1419	5.6 G0	.18	**+.040**	**8**	24
383	*ρ Geminorum*	23	+31 59	+32 1562	4.2 A8	.24	**+.051**	**8**	22
384	*Weisse* 1029	38	+39 49	+39 1998	6.8 F8	.68	**+.024**	**6**	18
385	25 *Cancri*	8 20	+17 23	+17 1842	6.2 F2	.24	**+.033**	**8**	20
386	*Groombridge* 1678	10 38	+46 44	+46 1657	5.3 F0	.28	**+.015**	**6**	16
387	Σ 1774	13 36	+51 1	+51 1859	6.3 F	.16	**+.046**	**10**	21
388	*ρ Herculis*	17 20	+37 14	+37 2878	4.5 A	.038	**−.009**	**9**	22
389	*Lalande* 32151	17 29	+63 56	+63 1358	7.4 G0	.21	**+.005**	**10**	25
390	*β* 1251	37	+16 0	+16 3256	5.6 F	.10	**+.026**	**10**	27
391	*β* 1255	18 52	+48 44	+48 2793	5.9 F	.14	**+.014**	**8**	20
392	*β Sagittæ*	19 37	+17 15	+17 4048	4.4 K	.038	**+.033**	**8**	19
393	*Lalande* 38287	58	+15 20	+15 4026	7.2 G5	.61	**+.021**	**10**	22
394	*Munich* 25146	20 30	+ 5 47	+ 5 4556	8.7 K2	.44	**+.001**	**9**	22
395	*Bradley* 2725	53	+48 49	+48 3249	6.0 K	.000	**+.003**	**7**	19
396	34 *Vulpeculæ*	21 17	+23 26	+23 4294	5.8 K	.25	**−.008**	**10**	27
397	*Groombridge* 3703	22 7	+50 20	+50 3602	5.4 A	.15	**+.004**	**8**	21
398	14 *Andromedæ*	23 26	+38 41	+38 5023	5.3 K	.29	**+.011**	**7**	19
399	27 *Piscium*	54	− 4 7	− 4 5996	5.1 F	.09	**+.015**	**8**	19

January 6, 1921.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN. WITH A $4\frac{1}{2}$ INCH REFRACTOR,

By A. W. QUIMBY.

1920	Time	New Grs.	Total Grs	Total Spots	Fac. Grs.	Def.
July 1	6	–	3	13	2	fair
2	7	–	3	12	2	fair
3	7	–	2	14	2	fair
4	5	1	3	17	2	fair
5	6	–	3	22	2	fair
6	7	–	3	13	2	fair
7	7	–	3	7	2	fair
8	7	1	3	8	2	fair
9	7	–	2	3	–	poor
10	7	–	2	6	1	fair
11	7	–	2	6	1	fair
12	11	–	2	4	–	fair
13	7	–	2	4	–	fair
14	7		1	1	1	fair
15	7	1	1	1	1	fair
16	7	–	1	1	1	fair
17	7	–	1	2	1	fair
18	7	2	3	8	2	fair
19	7	–	2	8	2	fair
20	7	–	2	6	1	fair
21	7	–	1	4		fair
22	6	1	2	10	1	fair
23	6	–	2	5	1	fair
24	7	–	2	4	1	fair
* 25	7	–	2	3	–	fair
* 26	7	1	3	4	1	fair
* 27	7	–	3	4	2	fair
* 28	7	–	3	4	1	fair
* 29	7	–	2	4	–	fair
* 30	7	–	2	3	–	fair
* 31	7	–	2	3	–	fair
*Aug. 1	7	–	2	3	–	fair
* 2	7	1	2	3	1	fair
* 3	7	–	2	2	1	fair
* 4	7	–	1	1	1	fair
* 5	7	–	–	–	–	poor
* 6	6	1	1	1	1	fair
* 7	6	–	–	–	–	fair
8	7	–	–	–	1	fair
9	7	–	–	–	–	fair
10	7	–	–	–	–	fair
11	5	1	1	3	1	fair
12	11	1	2	4	1	fair
13	4	2	4	6	2	fair

*With 2-inch refractor.

1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Aug. 14	12	–	4	9	1	fair
15	5	–	3	14	–	fair
16	9	–	3	15	–	fair
17	7	–	3	14		fair
18	5		2	11	–	good
19	2	–	1	1	–	poor
20	12	–	2	2	–	fair
21	7	–	1	1	–	fair
22	4	1	2	2	2	fair
24	10		1	2		fair
25	9	–	1	3	–	fair
26	9	–	1	3		fair
27	7	–	1	3	–	fair
29	5	–	1	5	2	good
30	5	–	1	10	1	fair
31	5	–	1	22	–	good
Sept. 1	7	–	1	12	–	poor
2	7	–	1	24		fair
3	5		1	32	–	fair
4	7	–	1	50		good
5	7	1	2	55	–	good
6	9	–	1	52		fair
7	7	–	1	48	1	fair
8	7	–	1	16	1	poor
9	7	1	1	4	2	fair
10	7	–	1	10	2	fair
11	7	–	1	8	1	fair
12	7	–	1	8	–	fair
13	7	1	2	12	–	fair
14	7	–	2	14	1	fair
15	7	–	2	20	1	fair
16	7	–	1	10	1	fair
17	7	–	–	–	1	fair
18	7	–	–	–	1	fair
19	7	–	–	–	1	fair
20	7	–	–	–	–	fair
21	7	1	1	1	1	fair
22	7	1	2	8	1	fair
23	7	–	2	12	1	fair
24	7	1	3	20	1	fair
25	7	–	3	12	1	poor
26	7	1	2	43	–	fair
27	3	1	3	40	–	fair
28	11	–	3	20	–	poor
29	10	–	3	27	–	poor

1920	Time	New Grs	Total Grs.	Total Spots	Fac. Grs.	Def.
Oct. 1	10	1	4	10	2	fair
2	7	–	3	13	2	fair
3	7		3	15	2	fair
4	7	2	5	18	3	fair
5	7	–	5	10	3	fair
6	7	–	2	7		fair
7	7	1	3	32	3	fair
8	7	–	3	23	1	fair
9	7		3	26	2	fair
10	7	1	4	12	1	good
11	7	–	3	60	1	good
12	7	–	3	36	–	fair
13	7	–	3	23	–	poor
14	7	–	3	20	1	poor
15	7	2	4	18	1	poor
16	7	1	3	17	2	poor
17	7		3	24	3	fair
19	7	1	3	13	2	fair
20	7		2	14	3	fair
21	7	1	3	30	4	fair
22	7	–	3	30	3	fair
23	7	2	3	45	2	fair
24	7	–	3	50	–	fair
25	11	–	3	56	–	fair
26	4	–	3	19	–	poor
27	12	–	2	11	–	poor
28	4	–	2	7	–	poor
29	7	–	2	5	1	poor
30	7	1	2	4	2	poor
31	7	1	3	20	3	fair
Nov. 1	7	–	2	46	1	fair
2	8	–	1	10	–	poor
3	7	–	2	26	–	poor
4	7	–	2	34	2	fair
5	7	–	2	30		fair
6	7	1	3	42		fair
7	8	–	3	20	–	poor
8	8	–	2	32	2	fair
9	8	–	1	2	–	poor
10	8	–	1	3	1	poor
12	7	1	1	2	2	fair
13	7	–	1	5	2	fair
14	8	1	2	4	2	fair
17	4	–	1	1	–	poor
18	8	–	1	1	1	good

1920	Time	New Grs	Total Grs.	Total Spots	Fac Grs.	Def.	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def	1920	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Nov. 19	8	–	1	1	–	fair	Dec. 6	8	–	1	2	1	poor	Dec. 19	8	–	2	10	–	fair
20	8	–	1	1	–	fair	7	11	–	1	2	1	fair	20	8	2	4	20	2	fair
21	8		1	1	–	fair	8	9	1	1	2	1	fair	21	8	–	4	17	3	fair
24	8	2	3	10	1	poor	10	12	–	1	2	–	poor	23	3	–	4	11	1	fair
25	8		3	13	1	poor	11	8	–	1	4	–	fair	24	8	1	4	17	1	fair
26	8	1	3	10	1	poor	12	8	–	1	4	1	fair	25	8	–	4	12	1	fair
Dec. 1	4	–	1	1	–	poor	14	8	–	1	2	1	fair	26	8	–	3	17	1	poor
2	8	–	1	2	–	poor	15	8	1	1	1	1	fair	28	8	–	4	26	2	poor
3	8	–	1	2	–	poor	16	8	–	–	–	1	fair	29	8	–	3	17	1	fair
4	8	–	1	2	–	poor	17	9	1	1	2	1	fair	30	8	–	3	17	1	fair
5	8	1	2	3	1	poor	18	9	2	3	14	1	fair	31	8	1	4	15	1	fair

OPPOSITION EPHEMERIS OF *EROS* (433), 1921,

BY FRANK E. SEAGRAVE.

The following ephemeris is based upon the elements given in the "Bahnelemente der kleinen Planeten," for 1920.

CONSTANTS

$$x = r[9.99464] \sin (34^\circ\ 16'\ 49''.94 + u)$$
$$y = r[9.94129] \sin (299\ \ 13\ \ 42\ \ .30 + u)$$
$$z = r[9.70854] \sin (319\ \ 41\ \ 37\ \ .84 + u)$$

Opposition-date, Sept. 6, 1921.

1921	α	δ	Log r	Log Δ
	h m s	° ′ ″		
July 23	23 41 46	+ 7 0 13.	0.23754	9.98409
27	23 41 45	+ 7 52 45.	0.23600	9.96672
31	23 41 4	+ 8 43 52.	0.23438	9.94938
Aug. 4	23 39 39	+ 9 33 14.	0.23266	9.93211
8	23 37 28	+10 20 10.90	0.23088	9.91512
12	23 34 30	+11 4 12.	0.22900	9.89861
16	23 30 44	+11 45 7.	0.22700	9.88265
20	23 26 11	+12 21 52.	0.22494	9.86759
24	23 20 50	+12 53 57.	0.22278	9.85358

1921	α	δ	Log r	Log Δ
	h m s	° ′ ″		
Aug. 28	23 14 47	+13 20 8.60	0.22056	9.84098
Sept. 1	23 8 7	+13 37 55.	0.21826	9.83001
5	23 0 57	+13 53 31.	0.21586	9.82082
9	22 53 30	+13 59 57.	0.21338	9.81369
13	22 45 56	+13 59 23.	0.21080	9.80859
17	22 38 28	+13 52 19.	0.20812	9.80567
21	22 31 18	+13 39 3.	0.20538	9.80499
25	22 24 37	+13 20 53.	0.20258	9.80636
29	22 18 34	+12 58 31.	0.19964	9.80960
Oct. 3	22 13 19	+12 33 15.	0.19664	9.81463
7	22 8 58	+12 6 33.	0.19356	9.82109
11	22 5 33	+11 39 15.	0.19038	9.82883
15	22 3 7	+11 12 38.	0.18714	9.83753
19	22 1 38	+10 47 20.	0.18378	9.84689
23	22 1 8	+10 24 28.	0.18038	9.85684
27	22 1 31	+10 3 54.	0.17688	9.86713
31	22 2 50	+ 9 46 48.	0.17332	9.87757
Nov. 4	22 4 56	+ 9 32 28.	0.16966	9.88808
8	22 7 51	+ 9 21 58.	0.16596	9.89850
12	22 11 29	+ 9 15 20.50	0.16218	9.90872
16	22 15 49	+ 9 12 25.	0.15834	9.91868

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ON THE DETERMINATION OF DOUBLE STAR ORBITS FROM INCOMPLETE DATA, FIRST PAPER, WITH AN APPLICATION TO THE ORBIT OF φ^2 *BOOTIS*.

By GEORGE C. COMSTOCK.

Burnham has protested frequently and vigorously against the practice of deriving double star orbits from observations covering only a small part of the periodic time in the orbit. In general one must agree with the justice of this criticism but it seems quite possible that it has been carried too far and that in many case a fair approximation to the desired orbit may be obtained from data that are quite incapable of yielding definitive results. The major difficulty in the case arises from the fact that the observations are of limited precision and that with reference to the errors inherent in them many different orbits can be found that will approximately satisfy the available data. This is peculiarly true when an apparent orbit is derived by plotting the observed positions of the stars and drawing through them, as the orbit, a smooth curve, each part of which depends mainly upon a few observations adjacent to it. The case would be much better if the apparent orbit could be made an ellipse each part of which depends upon, or at least is controlled by, all of the data.

As a contribution toward such a practice I give below, without demonstration, certain theorems based upon the geometry of the ellipse and the elements of the theory of elliptic motion. The fundamental principle lying back of them is that any relation connecting a recognizable peculiarity of stellar motion with a limited number (one, two, three,) elements of the star's true orbit constitutes an aid to the determination of that orbit or a control upon the accuracy of the elements when these have been otherwise found. Familiar illustration of such relations is furnished by the theorems that *(a)* In the apparent orbit the radius vector sweeps over equal areas in equal times, and *(b)* The diameter passing through the principal star is the projection of the major axis of the true orbit and is divided by the star into segments in the ratio $1 + e : 1 - e$, where e denotes the eccentricity of the true orbit. Few other relations of this kind seem to have found explicit recognition or common application, at least I can find little published reference to any of the following theorems. For their presentation I use the following notation: Ω, i, λ, e, a, T, are the common symbols for elements of the true orbit. In addition to these we put:

- a' Projection of the semi-axis major, a, upon the apparent orbit.
- b' Projection of the semi-axis minor.
- p' Projection of semi-latus rectum.
- φ Angle of eccentricity, $\sin \varphi = e$.
- A Fractional part of the total area of any ellipse included between the vertex and the latus rectum.
- s Apparent distance between stars.
- θ Any position angle.
- θ_p Position angle of p', etc.
- S Position of principal star.
- C Center of the apparent orbit.

Any chord of the apparent orbit drawn through S will be called a stellar chord.

Use will be made of the following recognizable features of the apparent orbit.

I. The projected latus rectum, p', is that stellar chord that is bisected by S. It is also the stellar chord so drawn that the area included between it and that part of the ellipse adjacent to the vertex is bisected by a'.

II. The diameter of the apparent orbit parallel to p' is b'.

III. If any number of mutually parallel chords be bisected their middle points will fall on and identify a

diameter of the apparent orbit. If these chords are parallel to p' the diameter determined by them is a'. If the chords are parallel to a' the resulting diameter is b'.

Theorems

1. In a system of oblique coördinates whose origin is at C, whose x axis is a' and y axis, b', let any chord parallel to b' be identified by the abscissa x' of the point in which it cuts a'. If tangents to the ellipse be drawn at the extremities of any such chord their intersection will fall on a' produced and the abscissa, x, of this point will satisfy the relation $xx' = a'^2$. If the chord in question be p' the last relation becomes

$$ex = a' \qquad (1)$$

Corollary. The diameter a' determined by bisecting any system of chords parallel to p', must, when produced, pass through the intersection of the tangents drawn at the extremities of each such chord. Through this relation the determination of a' may be much strengthened.

2. Let the distance CS be represented by μ and the distance from S to the intersection of the tangents drawn to the extremities of p' be called Δ, then

$$\begin{aligned} e^2 = \sin^2\varphi &= \mu/(\mu+\Delta) \\ \tan^2\varphi &= \mu/\Delta \end{aligned} \qquad (2)$$

3. Let q' denote the distance, s, between the stars when at periastron. We shall then have

$$q' = e\Delta/1+e \qquad (3)$$

Since the determination of Δ and the resulting value of e by theorem 2 have not involved the part of the orbit immediately adjacent to the periastron, equation 3 furnishes a control upon the construction of that part of the orbit that is needed in connection with the following theorem.

4. In the notation of theorem 1 let there be introduced an auxiliary angle ζ defined by the relation

$$x' = a'\cos\zeta$$

and denote by A the fractional part of the area of the ellipse included between the chord x' and the vertex of the ellipse. We shall then find

$$2\pi A = 2\zeta - \sin 2\zeta \qquad (4)$$

If the chord whose abscissa is x' be identified with p' we shall have $\cos\zeta = e$ and with this value of the argument A, has been computed from equation 4 and is tabulated below as a function of e.

Let a series of equidistant chords be drawn parallel to p' with the common distance between them, measured along a', equal to q'. The argument ζ corresponding the to nth such chord may be found from

$$\cos\zeta_n = ne - (n-1) \qquad (5)$$

through which and equation 4 the several areas, A_n, corresponding to the chords may be computed. Let us now put

$$\frac{A_n - A_{n-1}}{A_1} = R_1, n \qquad (6)$$

and tabulate R as a function of e as is done below in Table I. The use of the table is as follows: In any apparent orbit draw p' and draw also a second chord parallel to p' and cutting a' at a distance q' from S. Measure A_1 and A_2, *i.e.*, the areas included between these chords and the vertex, and by division find a numerical value for $R_{12} = (A_2 - A_1)/A_1$. With this value of R_{12} as argument the eccentricity of the orbit may be interpolated from Table I. A third chord may also be drawn at a distance $2q'$ from p' and used in a similar manner through the relations

$$A_3 - A_2/A_1 = R_{1,3}$$

The minor axis b' being a chord parallel to p' may be used in a manner similar to the above by means of the quantity R_1,b whose values are also given in Table I.

5. Let the observed times of transit of the *comes* past the extremities of a', b', p', (read from the θ-curve *i.e.*, a curve in which the position angles are plotted to the time as argument) be as follows:

Minor Axis, b', T_1 and T_5
Latus rectum, p', T_2 and T_4
Major axis, a', T_3

With these data we shall have

Periastron Passage:

$$T = T_3 = (T_4 + T_2)/2 = (T_5 + T_1)/2$$

Periodic Time: (7)

$$P = (T_4 - T_2)/A_1 = F(T_5 - T_1)/A_1.$$

The factor F required in the last of these equations,

$$F = 2\pi A_1/(\pi - 2e)$$

is tabulated in Table I.

This factor also satisfies the relation

$$F = (T_4 - T_2)/(T_5 - T_1) \qquad (8)$$

through which a value of the eccentricity, dependent only upon the observed times, may be found by interpolation from the table. Agreement between the different values of T and P found as above will serve as a useful control.

6. The area A_n included between the apastron part of the ellipse and a chord drawn through the vacant focus of the orbit parallel to b' equals A_1 but the relation of this area to the star's motion is wholly different from that which obtains for the corresponding segment adjacent to periastron. In Table I the column headed T_n shows the ratio between the periodic time and the time required by the star to traverse that part of the ellipse bounding A_n. It may be of use in those cases in which the available observations are so clustered about apastron as to permit a determination of the position of the vacant focus.

7. If we represent by α and β the semi-axes of any apparent orbit we may find the relation

$$\alpha^2 + \beta^2 = a'^2 + b'^2 = R^2 \qquad (9)$$

where R denotes the radius of an auxiliary circle whose center falls at the center of the ellipse. It is a property of this auxiliary circle that if there be drawn to the ellipse any two tangents that intersect at right angles, their point of intersection will fall on the circumference of this circle. By use of a straight edge and a draughtman's triangle applied to the observed path of the star, points on the auxiliary circle may very readily be found through this relation.

When observations covering a complete revolution in the orbit are available this theorem furnishes, through the use of dividers and the method of trial and error, an excellent graphical adjustment through which an ellipse may be found, every part of which depends upon all of the available data; *e. g.* draw the auxiliary circle by means of the intersections of tangents and within it draw from opposite extremities of a diameter two chords of lengths respectively equal to the apparent values of $2a'$ and $2b'$ or 2α, 2β. The free ends of these chords should coincide and if they do not fall at the same point an adjustment is called for, after which an ellipse may be drawn with the given center and the adjusted values of α and β. A corollary to the foregoing principle is: That chord of the auxiliary circle which passes through the periastron point perpendicular to a' equals $2b'$.

When the observations cover only a part of the orbit it is frequently possible to obtain a fair approximation to the auxiliary circle from its limited arc determined by the data.

8. Through the center of the apparent orbit draw a line parallel to p' in the direction whose position angle falls nearest to $90° + \theta\alpha$ and upon it locate the point B at a distance from the center equal to b' sec φ or p' sec^2 φ. Also represent by A the periastron point, *i.e.*, the extremity of a'. Introduce a system of rectangular coördinates whose center is at the center of the ellipse whose x-axis is parallel to the line of nodes, and in which the quadrants are so chosen that the y coördinate of A is a positive number. If the coördinates of A and B in this system are respectively x, y, ξ, η, they will satisfy the relation,

$$xy + \xi\eta = 0 \qquad (10)$$

Conversely, if by trial an axis is found for which this relation among the coördinates is satisfied one of the axes of this system, x or y, will be the line of nodes. A criterion by which to remove the ambiguity as to which axis should be chosen is furnished by the auxiliary quantity,

$$D = (x^2 + \xi^2) - (y^2 + \eta^2) \qquad (11)$$

If D is positive the line of nodes is parallel to the x-axis; if negative to the y-axis. In the latter case the names of the coördinates should be interchanged, x for y, η for ξ, before making further use of them.

The process of finding the line of nodes by the method of trial and error may be greatly facilitated by noting that the products xy and $\xi\eta$ represent respectively double the areas of the triangles formed by xya' and $\xi\eta b'$ (produced). If by means of a straight edge and a pair of draughtsman triangles xya' and $\xi\eta b'$ be made visible upon the paper containing the apparent orbit a fair approximation to an axis that will furnish this equality of the two figures may be made by mere inspection. Let the coördinates be measured with respect to an axis thus found and put

$$x\,y + \xi\,\eta = \sigma$$

The angle through which the x-axis must be turned to bring it into coincidence with the line of nodes and the resulting corrections to the coördinates may then

be read from a single setting of a slide rule through the following differential relations:

$$\frac{\Delta\,\theta}{+\,57.3} = \frac{\Delta\,x}{+\,y} = \frac{\Delta\,y}{-\,x} = \frac{\Delta\,\xi}{+\,\eta} = \frac{\Delta\,\eta}{-\,\xi} = \frac{\sigma}{D} \qquad (12)$$

9. The several coördinates of Theorem 9, when referred to the line of nodes are connected with the elements of the true orbit through the following relations:

$$\begin{array}{ll} a\cos\lambda = \;\;\; x & a\cos\lambda\cos i = \eta \\ a\sin\lambda = -\,\xi & a\sin\lambda\cos i = y \end{array} \qquad (13)$$

10. Let $X = \theta_a - \theta_p = \theta_b - \theta_a$, be the acute angle between the projected major and minor axes a', b' of the true orbit. It is related to certain elements of that orbit through the equation

$$\tan i \sin i \sin 2\lambda \tan X = 2 \qquad (14)$$

The angle λ is always well determined by equation 13 if the coördinates can be measured, but i will be poorly determined if the inclination is small. In such case we introduce into equation 14 the value of λ given by equation 13 and solve for i by the introduction of an auxiliary angle as follows:

$$\begin{array}{l} \cot\psi = \tan X \sin 2\lambda \\ \tan i \;= \sec\,(45^\circ + \tfrac{1}{2}\psi)\sqrt{\sin\psi} \end{array} \qquad (15)$$

The angle X furnishes immediately an indication of the smallest possible value of the inclination of the orbit plane, through the relation $i_{min} = K - X$ where K is a function of X which between the limits $30^\circ < X < 85^\circ$ does not differ more than 6° from its mean value of 110°. For $X = 90^\circ$ and $X = 0^\circ$, $K = 90^\circ$.

Table I

e	A_1		$R_{1,2}$	$R_{1,3}$	$R_{1,b}$	F	T_n	e
0.0	0.500	64	1.00	...	0.00	1.00	0.50	0.0
.1	.436	62	1.17	...	0.15	.93	.50	.1
.2	.374	62	1.30	...	0.34	.86	.49	.2
.3	.312	60	1.40	...	0.60	.77	.49	.3
.4	.252	57	1.48	1.28	0.99	.68	.48	.4
.5	.195	53	1.56	1.56	1.56	.57	.47	.5
.6	.142	48	1.62	1.78	2.52	.46	.45	.6
.7	.094	42	1.68	1.96	5.3	.34	.41	.7
.8	.052	33	1.74	2.11	8.6	.21	.36	.8
.9	.019	19	1.78	2.25	51.	.09	.27	.9
1.0	0.000		1.83	2.37	∞	0.00	0.00	1.0

11. Let that stellar chord of the apparent orbit which is perpendicular to the line of nodes be divided by S into the parts r and r', then will these parts satisfy the relation

$$a\cos^2\varphi\cos i\,(r + r') = 2rr' \qquad (16)$$

If the chord be taken parallel to the line of nodes the corresponding relation is

$$a\cos^2\varphi\,(r + r') = 2rr' \qquad (17)$$

For a first application of the theorems above set forth I have chosen the star μ^2 *Bootis*, Burnham *G. C.* 7259. Ten determinations of the orbit of this star are summarized by Lewis, *Memoirs R. A. S.*, Vol. LVI, p. 420, but all of them are curtly dismissed by Burnham, *G. C.*, p. 684, with the remark "Nothing whatever is known of any element of the orbit and nothing can be known for at least another half century." A feature common to most if not all of these determinations is their use of and dependence upon the somewhat uncertain observations made prior to 1825 and in particular degree they depend largely upon two isolated estimates of position angle made by W. Herschel. Although these early observations increase by forty years the time covered by the available data, I have deemed it best to reject them and for the present make use only of the observations subsequent to 1825 as collected by Lewis, *loc. cit.*, supplemented by 57 observations of my own, 1897 — 1919, in part unpublished, and a smaller number of observations by Aitken and Van Biesbroeck falling within the same period as my own. From Lewis' data I have rejected a half dozen printed results which are either too discordant or represent only a single night's work by a casual observer. The adopted position angles and distances, θ, s, reduced for precession to the equinox of 1900.0, have been separately plotted against the time as an argument, smooth curves drawn through the plotted points and a graphical adjustment of them made through the relation $s^2\,d\theta/dt = c$. It here becomes apparent that the discordances between the observed data and the rigorous condition thus sought to be imposed upon them is of a systematic character, the observed values of c presenting slight but distinct minima about the epochs 1860, 1910 and maxima near 1835 and 1885. The double amplitude of the variation is approximately five per cent of the mean value of c. It does not seem feasible to determine at this time whether this variability arises from perturbations in the motion of the star or from

an accumulation of fortuitous errors in the observations. I have sought to avoid its effect as far as possible by substituting for the observed distances, s, a curve deduced from the slope of the θ-curve using for this purpose an average value of the constant, $c = 0.0564$ square seconds per annum. The maximum discrepancy between the values thus obtained and a mean of those directly observed is $O - C = -0''.07$ for the epoch 1868.

Position angles and distances read from the adjusted curves for the beginning of each year whose number is a multiple of 5 were then plotted so as to show the relative positions of the stars upon a scale of $100^{mm} = 1''$, and a smooth curve was drawn through the resulting points. This curve was then tested by and adjusted to satisfy as nearly as possible the principles above set forth under III, 1, 2, 3. The resulting modifications of the curve caused it no longer to pass through all of the plotted points but its maximum departure from them is $0''.05$ for the poorly determined point of date 1830.0 and $0''.03$ for the epoch 1865.0.

To avoid the effect of prejudice sometimes alleged to exist in favor of the smallest orbit that will fit the data, I have at no time attempted to draw a complete ellipse to represent the orbit. The subsequent procedure relates to and involves only that part of the apparent orbit within the range of observation and defined above. Five points on the auxiliary circle having been plotted (theorem 7) the center, C, and radius, R, of the circle corresponding to them was found by trial and an independent determination of the center was made from theorem 1. The two determinations differ about 2^{mm} in fixing the position of the center of the orbit and provisionally I adopt a mean of the two results. This adopted position of C is now to be controlled through three different methods as follows:

(a) The projected latus-rectum and minor axis, p', b', are now drawn in accordance with 1 and the measured value of $2b'$ given directly by the plotted curve is compared with two values of its length obtained indirectly through theorem 7, as follows:

$2b' = 171.3^{mm}$	Measured value	
171.5	Th. 7	
170.3	Th. 7	Corollary

The agreement while not absolute seems adequate.

(b) We read from the plotted orbit position angles of the extremities of a', b', p', as shown below and find from the θ-curve the times corresponding to these position angles of the star, *viz.*

PERIASTRON PASSAGE

Point	θ	Date	T
b'	327.9	$1827.0 = T_1$	....
p'	294.1	$1845.2 = T_2$	....
a'	192.8	$1864.4 = T_3$	1864.4
p'	114.1	$1884.2 = T_4$	64.7
b'	70.2	$1902.1 = T_5$	64.6

From the observed times we find by equation 7, the times of periastron passage shown in the last column of the table. Here the agreement seems adequate.

(c) We find six nearly independent values of the eccentricity as shown in the following table where the last column indicates the relation employed for finding each value of e.

Theorem	e	Relation
1	0.54	μ, a'
.	.53	$p' : b' = \cos\varphi$
2	.54	μ, Δ
4	.53	$R_{1,\,2}$
4	.52	R_1, b
5	.55	F

The value last given is found from the dates used above in determining the time of periastron passage as follows:

$$F = 39.0 \div 75.1 = 0.52,$$

and by interpolation in Table I with this number as argument we find $e = 0.55$. The agreement *inter se* of the several values shown under (a), (b), (c), seems to constitute a substantial control upon the adopted position of the center of the orbit and I adopt from (c) as a definitive result $e = 0.53$.

Reverting to theorem 5 and to the times T_1, T_2, T_3 etc., above given, we now find for the periodic time in the orbit,

$$P = (T_1 - T_2)/A_1 = 39.0/0.179 \quad = 218 \text{ years}$$
$$= F(T_5 - T_1)/A_1 = 0.54 \times 75.1/0.179 = 226$$

The second determination is presumably the better and I adopt as a weighted mean result, $P = 224$ years.

Turning next to theorem 8, inspection of the plotted path of the star shows that the line of nodes must fall very near the position angle $\theta = 180°$. Putting $\sin\varphi = 0.53$ we find for the point B, $b' \sec\varphi = 101.0^{mm}$ and with this value we obtain for the coördinates,

$$x = +\ 123.3^{\mathrm{mm}} \qquad \xi = -\ \ 42.1^{\mathrm{mm}} \qquad D = +7707$$
$$y = +\ \ 28.5 \qquad \eta = +\ \ 92.5$$
$$xy = +3514. \qquad \xi\eta = -3894. \qquad \sigma = -\ 380$$

The positive sign of D shows that the line of nodes is adjacent to the x-axis. Equation 12 applied to these numbers furnishes the relations

$$\frac{\Delta\,\theta}{+\,57.3} = \frac{\Delta\,x}{+\,31.5} = \frac{\Delta\,y}{-\,122.5} = \frac{\Delta\,\xi}{+\,91.4}$$
$$= \frac{\Delta\,\eta}{+\,44.4} = \frac{-\,380}{+\,7707}$$

from which and equation 13 we obtain the following corrected coördinates and elements of the orbit. As a minor refinement I have used in determining Δx, a mean of the measured and corrected values of y, etc.

$$\Delta\theta = -\ \ 2^\circ.8 \quad x = +\ 121.74 \quad \xi = -\ \ 46.62$$
$$y = +\ 34.54 \quad \eta = +\ \ 90.31$$
$$\Omega = \ 177.2 \quad xy = +4205 \quad \xi\eta = -4210$$

$$\lambda = 21^\circ.0$$
$$i = 42.1$$
$$a = 130.3^{\mathrm{mm}}$$
$$= 1''.30$$

As a control upon the values of the elements thus found we have from the determinations of T,

$$X = \theta_a - \theta_p = 78^\circ.7$$

and from equation 15 with the value of λ found above we obtain $i = 41^\circ.9$ for comparison with the previous determination. I adopt as a definite result $i = 42^\circ.0$.

As a final control we have recourse to equation 16 and find for the stellar chord whose position angle is $87^\circ.2$

$$r = 56.3 \quad r' = 82.4 \quad \text{and}$$
$$\log a \cos^2\varphi \cos i\ (r + r') = 3.983$$
$$\log 2r\,r' = 3.970$$

The disparity between these numbers is of the same order of magnitude as that found among the checks hitherto applied.

The crucial point in the foregoing investigation is the adopted position of the center of the apparent orbit, C. No one of the methods employed for this purpose is conclusive or even satisfactory, but the agreement of the several values of the eccentricity above found from diverse data may be regarded as confirming the adopted position. In smaller measure a like conclusion may be drawn from the several values of b', T, P and i. Nevertheless, I have tried shifting the center, C, to and fro along the axis a' to determine within what limits its position may be varied without contradicting too strongly the direct testimony of the observations. Expressing the limits thus found in terms of the resulting eccentricity the conclusion is that

$$0.50 < e < 0.57.$$

I have determined the values of the orbit elements corresponding to these limits of e as shown in the following table for comparison with those resulting from the adopted value, $e = 0.53$.

Variation of e

e	0.50	0.53	0.57
	°	°	°
λ	20.5	21.0	20.1
Ω	177.6	177.2	177.4
i	43.0	42.0	41.1
a	1.24	1.30	1.36

It will be seen that those elements which fix the position of the orbit are but little influenced by the eccentricity and their values may be considered well determined. This is also true in principle of the time of periastron passage, T, but the periodic time and the major axis, P and a, are closely related to e and share in its measure of uncertainty.

Collecting results we have for the adopted elements of the orbit of μ^2 *Bootis*

$$P = 224 \text{ years}$$
$$T = 1864.6$$
$$\left.\begin{aligned} \Omega &= 177^\circ.2 \\ i &= \ 42^\circ.0 \\ \lambda &= \ 21^\circ.0 \end{aligned}\right\}\ 1900.0$$
$$e = \ \ 0.53$$
$$a = \ \ 1.30$$
$$n = -1^\circ.607$$

These elements are in fair accord with those of Jackson, *M. N.*, *R. A. S.*, March, 1920, but they agree even more closely with those obtained by See, Evolution of the Stellar Systems, a quarter century ago. Their detailed comparison with the data employed should yield residuals differing but little from those presented by See at p. 167 of the work cited. I therefore abstain from such a comparison but give below an ephemeris, 1900 — 1940, and a comparison of that ephemeris with the simple mean of the un-

adjusted observations subsequent to SEE's epoch, that were used in determining the apparent orbit. Compare the possibly systematic character of the values of O — C here shown with what is above noted as to the apparently variable areal velocity in this orbit.

I have also compared the adopted elements with the five observations made prior to 1825 which were not used in deriving the orbit, *viz.:*

Date	Obs'r	Nights	θ Obs'd	θ O — C.	s Obs'd	s O — C
			°	°		″
1782.68	H	1	357.2	−2.8	...	.....
1802.86	H	1	346.2	−2.6	...	.....
22.21	Σ	2	330.7	−3.3	..	.....
23.41	SH	3	333.7	+0.9	1.65	+0.36
24.44	S	5	333.5	+1.7	1.43	+ .17

The discordances here shown are somewhat less than those found by SEE from his orbit which is based upon these observations.

EPHEMERIS OF μ^2 *Bootis*

Date	θ	s	O — C	
	°	″	°	″
1900.0	75.6	0.95	−0.6	−.01
05	66.8	1.04	−1.8	−.02
10	59.8	1.13	−0.8	.00
15	53.5	1.22	+1.0	.00
20	48.1	1.31	....	....
25	43.5	1.40	....	....
30	39.5	1.48	....	....
35	35.8	1.55	....	....
40	32.2	1.62	...	....

Washburn Observatory,
February, 1921.

SEARCH EPHEMERIS FOR (925) *ALPHONSINA*,

BY BANCROFT WALKER SITTERLY.

This ephemeris is calculated from the elements published in the *Astronomical Journal*, No. 779, October 30, 1920. The time of opposition is May 21st, when the asteroid should be about the eleventh magnitude.

G. M. T.	α vera	δ vera	log r	log Δ
	h m s	° ′		
May 3.5	15 40 36	−49 25.3	0.4322	0.2604
7.5	36 3	49 16.2	.....	.....
11.5	31 19	49 1.8	0.4333	0.2546
15.5	26 32	48 42.1	.....	.....
19.5	21 49	48 17.5	0.4344	0.2524
May 23.5	15 17 16	−47 48.2	.....	.....
27.5	12 57	47 14.6	0.4355	0.2539
May 31.5	8 58	46 37.3	.....	.....
June 4.5	5 23	45 56.9	0.4365	0.2590
8.5	15 2 16	45 14.1	.....	.....
12.5	14 59 39	44 29.5	0.4376	0.2677
16.5	57 34	43 43.8	.....	.....
20.5	56 0	42 57.7	0.4386	0.2794
24.5	54 58	42 11.7	.....	.....
June 28.5	14 54 29	−41 26.4	0.4397	0.2936

Princeton University Observatory
March, 1921.

NOTE.

TO DOUBLE-STAR OBSERVERS:

In accordance with the wishes of my friend, the late PROFESSOR ERIC DOOLITTLE, and my promise made to him in 1919, I have undertaken the completion of the Extension to BURNHAM's General Catalogue of Double Stars upon which he had been engaged since 1913 when PROFESSOR BURNHAM turned over to him the data he had collected. This arrangement has PROFESSOR BURNHAM's cordial approval.

The work should be published at the earliest practicable date and I have DIRECTOR CAMPBELL's assurance of such assistance on the part of the Lick Observatory as may be needed to complete the manuscript for the printer.

I respectfully request all double star observers to coöperate by sending me copies of their papers printed in the present year as well as of those which they publish later.

ROBERT G. AITKEN.

Mount Hamilton, California,
November 5, 1920.

THE PARALLAX OF α ORIONIS,

BY OLIVER J. LEE.

An additional determination of the parallax of Betelgeuse has just been completed here and because of the extraordinary interest of this star it is published at this time. It was placed on the parallax program in October 1916. Sixteen plates, covering more than four years, aggregating 30 exposures and representing 7 epochs, were used. The resulting relative parallax is **+0″.017 ±0″.007.**

Four independent values of the parallax by three different methods are now available. They are

ELKIN: Heliometer.
+0″.024 ±0″.024, relative, or +0″.031 absolute

SCHLESINGER: Photography,
+0″.013 ±0″.007 +0″.018

ADAMS and JOY: SPECTROSCOPIC
. . . . +0″.012

LEE: Photography.
+0″.017 ±0″.007 +0″.022

Assuming, arbitrarily, a probable error of ±0″.004 for the spectroscopic value in this case, these give a mean of +0″.0154, absolute.

The first fruit of the labor of PROFESSOR MICHELSON and of his associates at Mount Wilson in observing angular stellar diameters is the value 0″.046 for Betelgeuse. Using this angle, the linear diameter is 2.98 astronomical units.

The value by ADAMS and JOY alone gives	3.8 A. U.
The mean of SCHLESINGER and LEE gives	2.3 A. U.
The value by ELKIN gives	1.5 A. U.

It is interesting to note in this connection that EDDINGTON predicted a diameter which is only 11 per cent. greater and RUSSELL predicted a value 34 per cent. smaller than that measured.

Yerkes Observatory,
February 24, 1921.

THE *PONS-WINNECKE* COMET,

BY FRANK E. SEAGRAVE.

DR. CROMMELIN has published the following approximate elements of the *Pons-Winnecke* Comet in the February, 1921, number of The Observatory:

T = 1921, June 15 ±10 days. Ω = 96°
q = 1.01 i = 19° 30′
ω = 174° π = 270

The following Ephemeris is based upon these elements:

1921	α	δ	log r	log Δ
	h m	° ′		
April 14	15 41	+41 26	0.12170	9.68996
18	15 48	+43 9	0.11078	9.66074
22	15 57	+44 51	0.09990	9.63021
26	16 6	+46 30	0.08912	9.59830
30	16 17	+48 8	0.07852	9.56439
May 4	16 29	+49 42	0.06818	9.52818
8	16 44	+51 13	0.05822	9.48918
12	17 2	+52 37	0.04870	9.44669

During the interval August 4–15 in 1918, the Comet was only a little more than ½ an astronomical unit from *Jupiter*, and the perturbations were large.

The following Ephemeris is based upon June 22, 1921, Gr. noon, as perihelion time.

1921	α	δ	Log r	Log Δ
	h m	° ′		
April 12	14 31	+44 15	0.14622	9.74784
16	14 31	+45 53	0.13556	9.72452
20	14 31	+47 26	0.12448	9.70075
24	14 30	+48 54	0.11352	9.67610
28	14 29	+50 16	0.10260	9.65045
May 2	14 28	+51 37	0.09178	9.62341
6	14 27	+52 40	0.08116	9.59461
10	14 26	+53 40	0.07072	9.56342

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ON THE PERIOD-ECCENTRICITY RELATION IN BINARY SYSTEMS,

BY RALPH E. WILSON.

For some years it has been considered as well established that the eccentricities in binary systems, spectroscopic and visual, increase in the mean with the periods. Largely because of the lack of data, further study of the peculiarities of this relation has been neglected, although in 1918 AITKEN published* tables, based upon 187 orbits, showing the trend of the increase and called attention to an apparent maximum of eccentricity in spectroscopic systems having periods from 20 to 50 days.

In seeking a possible explanation of the apparent non-uniformity of the curve representing the period-eccentricity relation, I have collected the data on 253 orbits now available. The eighteen *Cepheid* variables were rejected for obvious reasons, leaving 235 systems for consideration. Two° of these are triple systems in which two values each of period and eccentricity are available. Of the total 151 are spectroscopic systems. In order to secure fairly uniform weight for each period-group, the material has been divided into groups of 8–25, 25–100, days and 100 days to 5 years instead of 8–20, 20–50, 50–150 and 150+ days, as was done by AITKEN. All the spectroscopic binaries having periods greater than five years have been combined with the visual binaries in their respective groups. The mean eccentricities and the number of stars in each group are given in the third and fourth columns of Table I while the curve representing the period-eccentricity relation is shown in Fig. 1.

* "*The Binary Stars*," p. 197, 1918.

° *β Persei* and *κ Pegasi*.

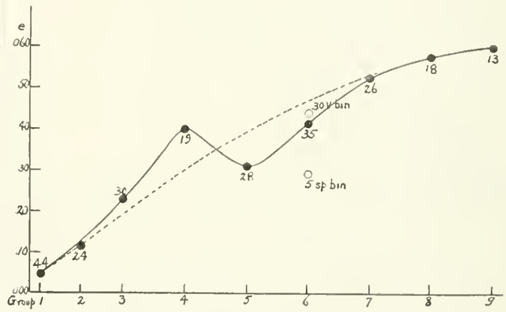

FIG. 1. Mean Period-Eccentricity Curve.

TABLE I. MEAN PERIOD-ECCENTRICITY RELATION

Group	Period		All		Type I		Type II		Giant		Dwarf	
1	0–4	days	0.046	44	0.044	37	0.057	7	0.047	38	0.010	1
2	4–8		115	24	109	20	142	4	114	19	020	3
3	8–25		231	30	268	18	176	12	250	22	132	4
4	25–100		403	19	473	14	208	5	468	15	010	1
5	100–5	years	311	28	395	13	239	15	394	16	420	1
6	5–50		416	35	405	6	418	29	433	11	414	24
7	50–100		530	26	555	6	522	20	612	8	494	18
8	100–200		580	18	574	5	583	13	626	7	552	11
9	>200		0.605	13	0.553	3	0.620	10	0.632	4	0.592	9
	Total			237		122		115		140		72

Not only is the maximum eccentricity for the group 25–100 days clearly shown but a minimum appears in the two succeeding groups. In AITKEN's grouping the same phenomena occur but the number of observations defining his groups is smaller. The phenomena seem to be independent of the method of grouping, unless of course the divisions are too comprehensive, and the number of observations appears to be sufficient to void a supposition of accidental error. The smoothness of the curve which it is possible to draw through the observations suggests that the departures from uniform increase of eccentricity with period may be due to some physical cause or causes.

If we separate the data into two classes, in one of which the principle star of the binary system is of spectral Type I and in the other of Type II, we get the data in columns five to eight, Table I, the curves representing the data being given in Fig. 2.

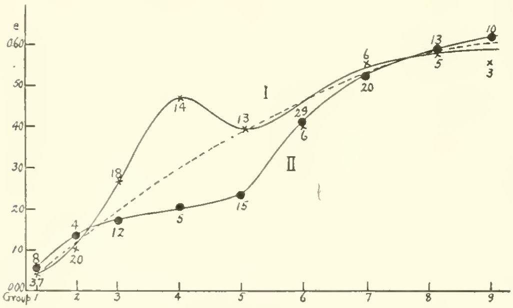

FIG. 2. Period-Eccentricity Curves — Types I and II.

A glance at the figure is sufficient to show that in spectroscopic binary systems with periods from eight days to five years the period-eccentricity relation differs radically for systems of Type I and Type II. The maximum from the curve representing uniform increase would appear to be due to systems of Type I and the minimum to systems of Type II. Among the visual systems with periods greater than 5 years and the short period spectroscopic systems there appears to be little difference between the two types. A partial explanation of this phenomenon is suggested by the fact that the stars of Type I are essentially all giant stars; their curve will respreent the period-eccentricity relation for the giant systems. The stars of Type II, on the other hand, are a mixture of giants and dwarfs. May not the curve for Type II systems combine relations essentially different?

The parallaxes, and consequently absolute magnitudes, of 59 of the systems under discussion are available. All the Class O – B5 and probably all the Class B8 – A5 systems, which cannot be definitely assigned dwarf classification, may reasonably be classified as giants. By means of the hypothetical absolute magnitudes of visual double stars recently published by JACKSON and FURNER* we are enabled to give giant or dwarf classification to all the visual systems. Using all the means cited and adopting absolute magnitude +2.5 as the dividing point, it has been possible to classify roughly as giant or dwarf 212 of the 235 systems. The mean eccentricities and the number of stars in each period-group are given in the last four columns of Table I while the data is depicted in Fig. 3.

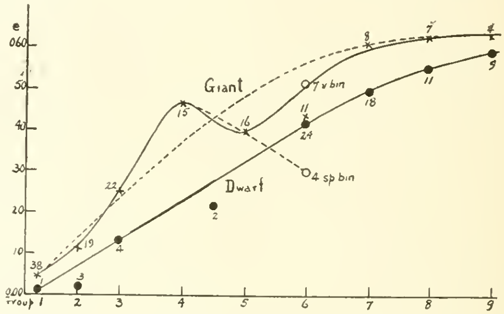

Fig. 3. Period Eccentricity Curves — Giant and Dwarf.

The curve representing the period-eccentricity relation for giant systems differs from the mean curve, Fig. 1, only in its greater slope in the shorter periods. The same maximum in Group 4 and minimum in Groups 5 and 6 appear. The lower end of the dwarf curve is ill-defined, especially in the critical Groups 4 and 5. Referring to Curve II, Fig. 2, we can scarcely doubt that the 15 stars of Group 5, the majority of which are in all probability dwarfs, must produce a minimum from the dwarf curve at that point. There is no evidence of a maximum from this curve. However, leaving these discordances for later consideration, it appears from the figure that there is a difference in the variation of eccentricity with period for giant and dwarf systems. All points on the dwarf curve lie definitely below the giant curve. That there should be such a marked uniformity in this phenomenon, especially at the upper and lower ends of the curves, is surprising. The use, however, of different criteria for classifying the systems as giants or dwarfs, such as the omission of systems with absolute magnitudes between 2.0 and 3.0 or the selection of a dividing point

* *Monthly Notices* 81, 22, 1920.

anywhere from 2.3 to 2.8, will not materially affect the curves and there can be little doubt that so far as our data goes, the curve representing the period-eccentricity relation for dwarf systems lies definitely below that for the giants. Thus the eccentricity in the giant systems appears to increase more rapidly in the shorter periods and to reach a maximum mean value of e in periods greater than 50 years. In the dwarf systems the eccentricity appears to increase more slowly and to reach approximately the same maximum mean value of e only in the very long periods. In view of the decided preference of the giant systems for the shorter periods and of the dwarfs for the longer ones, as evidenced by the numbers of systems in the various groups, a partial explanation of the non-uniformity of the mean curve, Fig. 1, is offered on the basis that the first half of the mean curve is largely due to the giant systems with eccentricities systematically higher than the mean and the second half to dwarf systems with eccentricities systematically lower than the mean.

There remain, however, the discordances from both the giant and dwarf curves which in themselves would tend to produce in the mean curve non-uniformity, not as pronounced perhaps, but similar to that which is found. It is clear that the break occurs in the groups where we pass from spectroscopic to visual systems. The first five groups are composed entirely of spectroscopic systems, the last three, of visual. Group 6 contains 5 spectroscopic and 30 visual systems. The mean eccentricity of the former is 0.28 and of the latter 0.44. The positions of the two groups are indicated by the open circles in Fig. 1 and similarly for the giant systems in Fig. 3. There can be little question that the mean eccentricity in the long period spectroscopic systems of which the orbits have thus far been determined is not only less than that of the visual systems but is also less than that of the spectroscopic systems in the two preceding groups. This leads to the suggestion that the minimum in Groups 5 and 6 is due not only in part to the inclusion of a large number of dwarf systems with systematically low eccentricities but also to the probability of the discovery of spectroscopic binaries with certain characteristics.

Table II. Amplitude of Velocity Variation

	1		2		3		4		5		6	
	km	no	km	no	km	no	km	no	km	no	km	no
B	80	16	85	12	68	6	67	4	35	7	.	.
A	65	21	59	8	41	12	42	10	30	6	6	1
F-G	47	7	48	5	42	6	24	4	18	6	8	1
K-M	..	..	..	..	24	4	32	1	16	9	4	4
All	67.7	44	69.4	25	44.6	28	42.5	19	25.0	28	4.8	6

In Table II are given the mean amplitudes of velocity variation, orbital velocities, of the spectroscopic binaries under consideration for the various period-groups and spectral types. The table shows clearly a decrease in velocity in orbit with type but, independent of this, it shows a decrease in orbital velocity with period. In the systems of short period the orbital velocities are large and the orbits small. Spectroscopic binaries are readily discovered in a short period of time, while the components of the system are too close together to be recognized as visual binaries. In systems of somewhat longer periods the orbital velocities, and the consequent probability of recognition as spectroscopic binaries in the limited time radial velocity work has been carried on, are less, the components still being too close together to be separated visually. Naturally the less eccentric orbits, in which the change of radial velocity is more nearly uniform, are more readily discovered than the more eccentric orbits, where an outstanding observation may for some years be attributed to an accidental error. Among the longer periods the orbits have increased in size, the average velocities in orbit are so small that only the least eccentric systems will be recognized as spectroscopic binaries, while in many of the more eccentric systems the components will be recognized at greatest elongations as visual binaries. It is not probable that many systems with periods over 50 years will be detected by purely spectroscopic means and their orbits will not be available to this generation.

Thus it is readily conceivable that up to a certain length of period essentially all the spectroscopic binaries among the stars observed are recognized as such. Beyond that point not all of them are recognized and the ones most liable to discovery are

those with comparatively low eccentricities. Thus at some point we should have an apparent maximum on the curve representing the increase of eccentricity with period. This point appears to be in the periods between 25 and 100 days. The falling off after that is rapid and the apparent minimum from the mean curve in the two succeeding groups is partly due to this cause.

Though the data is too meagre perhaps to warrant any definite conclusions, the indications are then, (1) that the relatively rapid increase in eccentricity in the first four period-groups is due almost wholly to the predominance of giant systems in these groups and consequently that an increase in the number of dwarf systems would tend to reduce the apparent maximum in Groups 3 and 4: (2) that the minimum in Groups 5 and 6 is due partially to the systematically low eccentricities of the dwarf stars in these groups and partially to the greater probability of the discovery of the less eccentric orbits among the long period spectroscopic binaries. As more spectroscopic binaries with long periods are discovered or as orbits are determined for many which are now recognized as long period systems, it is probable that most of the discordances from a uniform mean period-eccentricity curve will be removed, especially when there is taken into account a probable difference in the period-eccentricity relation for giant and dwarf systems.

MICROMETRIC MEASURES OF DOUBLE STARS, MADE WITH THE 12-INCH REFRACTOR AT THE WASHBURN COLLEGE OBSERVATORY,

By EDISON PETTIT.

The following list of 95 stars was measured principally with the 12-inch refractor at Washburn College. A few stars discovered with this telescope have been appended to the list of catalog stars.

The identification number for each star refers to BURNHAM'S *General Catalog*, and where this is not the case the position of the star is given.

The first column gives the date, the second the position angle in degrees, and the third the distance in seconds of arc. In all cases four settings were made in both position angle and in distance.

80 Hn 1

1917.742	10.6	2.48
.830	9.9	2.44
.849	14.1	2.32
1917.807	11.5	2.41

Companion faint.

.... ρ 106

R. A. $6^h\ 47^m.5$
Dec. $+19°\ 15'.2$

Mags. 10 — 10.3

1917.074	105.7	2.64
.104	101.4	2.46
.126	101.9	2.59
1917.101	103.0	2.56

474 Σ 69

1917.783	17.6	24.56
.786	17.1	24.44
.849	18.3	24.59
1917.806	17.7	24.53

482 Σ 73 36 *Andrm.*

1917.830	50.1	0.81
.912	48.0	0.77
1917.871	49.0	0.79

1070 OΣ 38 γ *Andrm.*

AB

1916.882	60.6	10.09
1917.063	62.5	10.28
.099	64.8	10.22
1917.015	62.6	10.20

BC

	110.6	0.63
	110.5	0.69
	111.7	0.68
	110.9	0.67

1223 *A.G.* 37

1916.995	293.5	4.64
1917.063	290.8	4.67
.071	292.9	4.58
1917.043	292.4	4.63

β gives this *B.D.* 31° 412. This is evidently a misprint; star is *B.D.* 33° 412.

1487 Σ 325

1917.739	179.0	10.96
.830	180.9	10.70
.912	180.6	10.92
1917.827	180.2	10.86

1490 Σ 326

1917.739	216.3	8.46
.830	217.0	7.82
.912	218.7	7.59
1917.827	217.3	7.96

1494 Ho 317

1917.739	310.0	3.63
.912	307.8	3.78
.956	308.8	4.07
1917.869	308.9	3.83

1496 *A.G.* 59

1917.739	89.9	25.25
.830	89.8	25.42
.855	90.0	25.50
1917.808	89.9	25.39

1525 *A.G.* 60

1917.739	160.9	6.80
.830	159.7	6.47
.855	159.8	7.08
1917.808	160.1	6.78

2027 OΣ 531

1916.882*	122.1	1.29
1917.003	120.4	1.33
.063	121.8	1.54
1916.983	121.4	1.39

*Primary looks elongated.

2112 Ho 507

1917.739	34.5	5.96
.769	31.9	5.45
.956	32.4	6.22
1917.855	32.9	5.88

.... Espin 223

R.A. $0^h\ 40^m\ 27^s.8$
Dec. 38° 9′.0
Mags. 9.3 — 9.4

1916.885	263.8	4.58
1917.003	263.6	5.01
.099	262.8	4.88
.104	263.0	4.71
1917.023	263.3	4.80

2161 Σ 535 230 *Tauri*

1917.726	321.7	1.86
.830	323.8	1.49
.832	323.7	1.23
1917.796	323.1	1.53

Companion has relative linear motion of 1″ in 86 years.

D.M. 38(999) R.J. 32

R.A. $4^h\ 53^m\ 00^s.4$
Dec. 38° 02′.6
Mags. 9.0 — 12.0

1916.882	288.9	2.44

2689 *A.G.* 94

1917.129	108.1	2.13
.200	104.6	2.75
.228	105.1	2.33
1917.186	105.9	2.40

4353 Σ 1161

1917.269	195.2	2.92
.293	195.8	2.76
.299	195.1	2.71
1917.287	195.4	2.80

.... Espin 179

R.A. $7^h\ 48^m.7$
Dec. 38° 2′.6
Mags. 9.5 — 9.5

1917.003	270.8	4.71
.071	270.1	4.28
.066	272.1	4.53
1917.047	271.0	4.51

Announced by Espin, but not measured by him.

.... Espin 292

R.A. $8^h\ 3^m.6$
Dec. 38° 28′.7
Mags. 8.5 — 10.0

1917.003	167.2	2.58
.066	166.8	2.63
.071	166.1	2.57
1917.047	166.7	2.59

Espin's measures are:

1906.18	165.7	2.50

Mags. 8.5 — 9.1

4717 Ku 32

1917.143	170.9	1.63
.151	171.4	1.50
.181	170.5	1.69
1917.158	170.9	1.61

5061 β 338

1917.129	275.7	7.20
.189	274.8	6.42
.200	275.0	6.93
1917.173	275.2	6.85

5071 Σ 1348 116 *Hydræ*

1917.269	322.4	1.76
.285	321.7	1.60
.293	322.2	1.74
1917.283	322.1	1.70

6182 Σ 1744 ζ *Ursæ Maj.*

AB

1917.370	71.9	11′ 51″.46
.373	71.6	11′ 50″.40
.378	71.9	11′ 52″.27
1917.374	71.8	11′ 51″.38

AC

	149.9	14.23
	150.1	14.71
	151.2	14.47
	150.4	14.47

6658 A 568

1917.348	323.6	2.26
.351	321.1	1.71
.359	322.5	2.39
1917.353	322.4	2.12

6746 Σ 1808

1917.299	74.2	2.31
.302	75.3	2.73
.304	74.8	2.54
1917.302	74.8	2.53

6776 Σ 1820

1917.228	84.5	1.92
.236	82.1	1.77
.238	84.1	1.94
1917.234	83.6	1.88

6780 Σ 1819

1917.293	340.6	1.15
.302	341.3	1.29
.340	343.9	1.26
1917.312	341.9	1.23

7251 Σ 1937 η *Coronæ*

1917.348	66.4	0.79
.359	66.6	0.77
.362	69.2	0.89
1917.356	67.4	0.82

7259 Σ 1938 μ^2 *Bootis*

1917.348	53.6	1.42
.359	50.2	1.43
.362	54.3	1.40
1917.356	52.7	1.42

7273 Σ 1944

1917.348	324.7	1.08
.359	324.9	1.20
.362	324.9	1.23
1917.356	324.8	1.17

7276 OΣ 296

1917.348	303.9	1.71
.359	300.1	1.74
.362	297.9	1.85
1917.356	300.6	1.77

7318 Σ 1954 δ *Serpentis*

1917.302	181.4	3.92
.343	182.1	3.86
.351	184.5	3.76
1917.332	182.7	3.85

Both stars orange.

7332 OΣ 298

1917.375	197.9	1.17
.389	199.2	1.01
.706	197.3	1.29
1917.490	198.1	1.16

5173 O. Stone 19

1917.293	267.5	2.47
.302	264.9	2.44
.307	269.1	2.45
1917.301	267.2	2.45

5210 H 4261

1917.293	84.8	8.12
.302	85.3	8.10
.307	84.4	8.27
1917.301	4.8	8.168

5365 OΣ 215

1917.348	200.4	1.08
.359	201.1	1.13
.367	200.9	1.16
1917.358	200.9	1.12

5501 Σ 1454

1917.271	321.1	2.88
.302	323.5	2.48
.340	322.2	2.58
1917.304	322.3	2.65

Colors orange and white.

5507 H 835

1917.307	323.3	1.35
.329	322.3	1.20
.343	324.3	1.45
1917.326	323.3	1.33

5539 Σ 1466 35 *Sextantis*

1917.313	240.0	6.89
.329	240.8	6.77
.340	238.7	6.81
1917.327	239.8	6.82

5633 Σ 1500

1917.302	310.7	1.56
.307	310.5	1.56
.329	311.2	1.48
1917.313	310.8	1.53

Both stars white.

5734 Σ 1523 ξ *Ursæ Maj.*

1917.343	111.6	3.43
.348	111.9	3.19
.356	110.3	3.07
1917.349	111.3	3.23

5773 H 840 γ *Crateris*

1917.238	99.7	5.29
.241	98.1	4.99
.269	99.5	5.22
1917.246	99.1	5.17

5782 A 138

1917.329	216.7	1.36
.340	214.2	1.34
.343	212.6	1.40
1917.334	214.5	1.37

6174 Σ 1643

1917.200	34.7	1.95
.225	33.5	1.73
.238	34.2	1.78
1917.221	34.1	1.82

6406 Σ 1728 42 *Comæ*

1917.367	12.5	0.30
.406	15.1	0.30
1917.386	13.8	0.30

Distance estimated.

7368 Σ 1967 γ *Coronæ*

1917.389	109.9	0.79
.808	110.7	0.80
1917.598	110.3	0.79

7459 Σ 1991

1917.378	198.6	3.12
.389	198.4	3.05
.406	199.2	3.10
1917.391	198.7	3.12

7717 Σ 2084 ζ *Herculis*

1917.343	105.6	1.52
.348	98.6	1.45
.356	102.3	1.46
1917.349	102.2	1.48

7854 Σ 2119

1917.359	10.9	2.22
.706	12.6	2.36
.723	13.6	2.29
1917.596	12.4	2.29

7858 Σ 2120

1917.359	238.7	10.12
.375	240.0	10.10
.389	239.4	10.40
1917.374	239.4	10.21

7863 β 823

1917.359	28.3	0.95
.482	27.2	0.97
1917.420	27.6	0.96

The second measure was made with the 40-inch at Yerkes. Declination given wrong sign in B.G.C. The following measures have been published:

Burnham		
1881.39	353°.9	1″.04
Doolittle		
1903.46	11°.8	1″.03
Aitken		
1910.54	18°.0	0″.91

The star is probably in rapid motion.

7885 β 1118 η *Ophiuchi*

1917.359	239.2	0.45
.706	243.0	0.82
.808	239.5	0.81
1917.624	240.6	0.69

Distance increasing, angle decreasing.

.... A 1145

R.A. 17h 02m.0
Dec. − 0° 55′.2

1917.359	226.8	0.48

Observed on three nights with the 40-inch but seeing too poor to test separation.

Aitken gives

1905.41	240.8	0.44

7887 β 124

1917.359	266.4	0.92
.482	264.0	0.94
.706	265.4	1.01
1917.516	265.3	0.96

8055 OΣ 331

1917.359	343.3	1.13
.704	340.4	1.19
.706	344.3	1.39
1917.590	342.7	1.24

8162 A Clark 7 μ *Herculis*

AB

1917.720	205.5	0.56
.739	208.0	0.92
1917.730	206.8	0.74

AC

	245.7	33.28
	245.8	33.15
	245.8	33.21

8197 Σ 2233

1917.359	70.5	2.36
.704	64.8	2.26
.706	65.0	2.28
1917.590	66.8	2.30

9602 Σ 2576

1917.701	98.1	2.27
.704	100.3	1.98
.715	99.1	2.19
1917.707	99.2	2.15

9605 Σ 2579 δ *Cygni*

1917.698	280.4	2.02
.701	284.7	2.17
.704	278.9	2.04
1917.701	281.3	2.08

9606 A 274

1917.704	63.3	3.72
.709	69.9	3.65
.720	72.5	4.69
1917.711	68.6	4.02

Strongly suspect the primary to be double.

9613 OΣ 385

1917.698	54.2	1.02
.701	52.3	1.29
.704	50.8	1.25
1917.701	52.4	1.19

9614 H 1438

1917.701	344.6	11.61
.704	342.1	11.88
.715	343.8	11.66
1917.707	343.5	11.75

9617 Σ 2580 χ *Cygni*

1917.704	70.7	25.83
.709	70.9	26.02
1917.706	70.8	25.92

9964 A 384

1917.715	356.8	1.21
.720	355.6	1.10
.736	354.7	1.06
1917.724	355.7	1.12

9983 Σ 2643

1917.726	77.2	3.17
.736	77.1	3.10
.739	73.8	3.21
1917.734	76.0	3.16

10300 H 1527

1917.745	281.2	9.08
.769	284.7	9.14
.780	282.5	8.90
1917.765	282.8	9.04

10305 Σ 2695

1917.745	79.7	1.03
.772	85.0	1.25
.830	76.2	1.00
1917.782	80.3	1.09

10327 Σ 2698

1917.745	304.4	4.47
.756	304.0	4.41
.769	306.1	4.37
1917.757	304.8	4.42

10335

1917.783	47.6	55.94
.849	47.8	56.48
.851	47.8	55.84
1917.828	47.7	56.09

Faint companion. This pair on parallax programs, but no determination yet. Relative motion of companion seems to be rectilinear. Its minimum distance will be 55″ in 34° in 1943.

10353 H 1544

1917.745	231.1	8.31
.756	231.5	8.48
.769	231.8	8.29
1917.757	231.5	8.36

10355 *A.G.* 258

1917.745	11.3	4.17
.769	9.5	4.11
.775	10.4	4.15
1917.763	10.4	4.14

.... Espin 207

R.A. $21^h\ 6^m.4$
Dec. 37° 51′.0
Mags. 9.2 — 9.7

1917.063	250.4	2.82
.099	250.2	2.55
1917.081	250.3	2.68

Espin's measures are:

1904.45	244.3	2.65

Mags. 9.5 — 9.6

11055 Ho 604

1917.742	317.5	5.27
.769	318.7	4.83
.783	317.6	5.05
1917.765	317.9	5.05

11065 H 1659

1917.742	299.2	7.16
.753	300.1	7.22
.769	298.2	7.27
1917.755	299.2	7.22

11089 Σ 2810

1917.742	290.9	17.00
.753	290.9	16.90
.769	290.5	17.11
1917.755	290.8	17.00

11555 Ho 178

1917.726	224.8	3.51
.739	227.3	3.22
.745	222.5	3.26
1917.737	224.9	3.33

No motion since 1892.

11741 Σ 2910

1917.786	341.2	5.31
.846	338.6	5.40
1917.816	339.9	5.36

11906 Σ 2932

1917.780	280.2	20.51
.846	281.4	20.76
1917.813	280.8	20.63

11916 Σ 2936 215 *Aquarii*

1917.780	51.1	4.60
.786	48.2	4.87
.846	47.5	4.85
1917.804	48.9	4.77

11977 β 1145

AB

1917.739	155.2	0.99

AC

	179.8	22.07

11982 H 1811

1917.739	155.9	6.21
.742	156.2	6.85
.753	154.9	6.41
1917.745	155.7	6.49

11983 H 1813

1917.739	61.4	9.59
.742	63.3	9.79
.753	62.1	9.87
1917.745	62.3	9.75

11987 Ho 190

1917.783	156.2	2.32
.786	154.3	2.26
.808	154.4	2.25
1917.792	155.0	2.28

11990 H 1814

1917.739	255.2	7.52
.742	252.9	7.68
.753	252.7	7.75
1917.745	253.6	7.65

11995 β 846

1917.739	91.4	1.83
.808	90.2	2.04
1917.774	90.8	1.94

11999 H 1817

1917.739	239.9	11.47
.742	240.2	11.98
.753	239.4	11.34
1917.745	239.8	11.60

12010 β 1332

AB

1917.783	130.1	1.62
.830	131.7	1.79
.843	134.9	1.54
1917.819	132.2	1.65

C could not be seen. No motion since 1902.

12531 Σ 3033

1917.698	8.7	3.36
.723	9.3	3.33
.736	4.8	3.43
1917.719	7.6	3.37

Given very white in *B.G.C.* Certainly is yellow now.

The following stars were discovered with the 12-inch and checked by Professor Doolittle:

(1)

R.A. $8^h\ 11^m\ 46^s.4$
Dec. 38° 00′ 01″.3
Mags. 10.2 — 10.2

1917.003	188.1	2.71
.074	186.2	2.52
.071	181.5	2.62
1917.049	185.3	2.62

(2) D.M. 38(1898)

R.A. $8^h\ 13^m\ 19^s.9$
Dec. 38° 20′.6
Mags. 9.0 — 9.0

1917.003	187.4	4.51
.071	181.8	4.33
.074	182.4	4.19
1917.049	183.9	4.34

(3)

R.A. $11^h\ 25^m\ 04^s.32$
Dec. 63° 16′ 30″.7
Mags. 11.0 — 11.0

1917.074	170.2	3.58
.189	175.2	4.65
.200	174.6	4.53
1917.154	173.3	4.35

(4) S.D. −19(3494)

*R.A. $12^h\ 20^m\ 59^s.7$
Dec. −19° 46′ 10″.8
Mags. 9.0 — 10.2

1917.238	325.8	4.56
.269	326.5	4.63
.271	328.9	4.53
1917.259	327.1	4.57

*Doolittle gets R.A. $12^h\ 21^m\ 02^s.3$.

(5)

R.A. $14^h\ 40^m\ 09^s.16$
Dec. 60° 45′ 08″.7
Mags. 10.4 — 10.4

1917.228	174.9	3.57
.236	174.8	2.99
.238	177.9	3.78
1917.234	175.9	3.45

Mt. Wilson Observatory,
March 14, 1921.

INVESTIGATION OF THE SECULAR VARIATIONS OF THE ELEMENTS OF (133) *CYRENE* PRODUCED BY THE ACTION OF *JUPITER* AND *SATURN*.

By CHARLES H. DAVIS.

The following secular variations of the elements of *Cyrene* produced by *Jupiter* and *Saturn* were computed by the method developed by Hill in Vol. I of the *Astronomical Papers of the American Ephemeris and Nautical Almanac.* The elements of *Jupiter* and *Saturn* employed in this work were obtained by reducing Hill's elements for 1850 to the adopted epoch by Leverrier's variations, while those of *Cyrene* were taken from the Tables of *Cyrene* contained in Vol. X of the *Memoirs of the National Academy of Sciences,** and reduced to the mean equinox and ecliptic of 1896.942 Berlin Mean Time.

Elements for the Epoch 1896.942 B. M. T.

	Cyrene	*Jupiter*	*Saturn*
π =	246° 27′ 58″	12° 39′ 46″	91° 1′ 46″
Ω =	321 8 11	99 24 26	112 45 25
i =	7 13 54	1 18 32	2 29 33
e =	0.1361287	0.04833205	0.05589998
n =	241671.50	109256.64	43996.204
log a =	0.4862475	0.7162374	0.9794957
M =		$\frac{1}{1047.35}$	$\frac{1}{3501.6}$

Secular Variations

	Action of *Jupiter*	Action of *Saturn*
$\frac{de}{dt}$ =	+ 1.03179	−0.03755
$\frac{d\pi}{dt}$ =	+ 71.1152	+2.1150
$\frac{di}{dt}$ =	− 0.60506	−0.03343
$\frac{d\Omega}{dt}$ =	−115.816	−3.0256
$\frac{dL}{dt}$ =	− 75.5728	−2.5813

* Seventh Memoir: *Tables of Minor Planets Discovered By James C. Watson;* by A. O. Leuschner.

These values were obtained from the division of the circumference into twenty-four parts, or every 15° of the eccentric anomaly of *Cyrene*.† Vega's seven place Log. Tables were used for the work. As a check against errors, a duplicate computation of R_0, S_0, and W_0 corresponding to four values of E, namely 0°, 90°, 180°, and 270° was made by the formulae given in the addendum to Hill's memoire. The quantities R_0 and S_0 were also checked by computing da/dt. During the course of the preceding duplicate work it was discovered that the functions $x(\tau)$, $\psi(\tau)$ and V can be found much more expeditiously by the following formulae:

First: Take out the values of the three elliptic integrals from Hill's Tables by means of the argument θ' given by the equation

$$\sin^2\theta' = \frac{G' + G''}{G + G''} = \frac{\cos\left(60° - \frac{\theta}{3}\right)}{\cos\frac{\theta}{3}}$$

Where θ is that given by Hill's formulae

$$\sin\theta = r/q^3$$

Then

$$x(\tau) = \frac{\mathfrak{R}\mathfrak{L}}{\left(2\sqrt{3}\cos\frac{\theta}{3}\right)^{\frac{7}{2}}}$$

$$\psi(\tau) = \frac{\mathfrak{R}\mathfrak{N}}{\left(2\sqrt{3}\cos\frac{\theta}{3}\right)^{\frac{5}{2}}} - 2x(\tau)\sin\left(60° + \frac{\theta}{3}\right)$$

$$V = \frac{\mathfrak{R}\mathfrak{N}}{\left(2\sqrt{3}\cos\frac{\theta}{3}\right)^{\frac{5}{2}}} - x(\tau)\left[2\sin\left(60° + \frac{\theta}{3}\right) - \frac{P}{q}\right]$$

† The values produced by the action of *Saturn* were obtained from the division of the circumference into twelve parts.

Providence, R. I.,
April, 1918.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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PERSONAL ERRORS IN THE USE OF A SELF-REGISTERING MICROMETER,

By J. C. HAMMOND.

[Communicated by Rear Admiral J. A. Hoogewerff, U. S. Navy, Superintendent, U. S. Naval Observatory.]

The following results are derived from investigations and observations made with the 6-inch transit circle of the U. S. Naval Observatory during the years 1911 to 1918, in the course of the determination of the positions of the standard stars contained in the *American Ephemeris* and in the lists of Boss, Backlund and Hough. The instrument is equipped with a hand-driven self-registering micrometer of the Repsold type made by the Warner and Swasey Company of Cleveland. A close pair of threads is used to follow the star and a reversing prism is attached in front of the eye-piece, all observations being made with the prism in two positions to eliminate errors due to bisection and the direction of motion of the star.

Absolute Personal Equation

The absolute personal equations of five different observers were determined with a personal equation machine made by the instrument maker of the Naval Observatory. This machine was described by Professor F. B. Littell in a paper read before the Astronomical and Astrophysical Society of America during its meeting at Washington, D. C., in 1911. The essential feature is a carriage which carries an artificial star alternately east and west across the line of sight of the telescope and which causes an automatic record to be registered on the chronograph. The speed of the artificial star can be varied to correspond to that of any star and it is observed in the same manner as a real star. By comparing the record with the automatic one made by the carriage, the observer's absolute personal equation can be determined.

The following table gives the absolute personal equations of the five observers for stars of different declinations. The signs are such as to make them applicable to observed transits.

Corrections for Absolute Personal Equation

Decl.	Hammond	Frederickson	Rines	Wylie	Aston
°	s	s	s	s	s
0	−.018	−.026	−.012	−.011	−.021
40	−.012	−.023	−.011	−.006	−.013
60	−.011	−.021	−.008	−.001	−.007
80	−.02	−.01	.00	+.02	+.02
85	−.02	+.01	+.02	+.05	+.06

An inspection of this table shows that each one observes the transit of a star too late, with the possible exception of stars near the pole, and that the amounts do not vary much for the different observers. There is some evidence that for slow moving stars near the pole there is a tendency, at least on the part of some observers, to get ahead of the star. The evidence is not conclusive on this point however as the personal equations for stars of declination 80° or more are not as well determined as the others.

The absolute personal equation in observing the *Sun*, as determined for four observers by attaching a brightly illuminated disk representing the *Sun* to the carriage of the personal equation machine, are as follows:

Absolute Personal Equations in Observing the *Sun*

Hammond	Frederickson	Wylie	Aston
s	s	s	s
−.016	−.037	−.031	−.023

It will be seen that, for each observer, these personal equations are nearly the same as for stars of the same declination.

Relative Personal Equation

The relative personal equations of the various observers were derived from the observations of the clock stars by taking the clock correction of one and carrying it forward by means of the clock rate to the clock correction as determined by some other observer. In no case was this done when the interval exceeded 24 hours, so that any error in the result introduced by the clock will be negligible. Weight 2 was given when observers worked on the same night and weight 1 when the interval was approximately one day.

The corrections to be applied to observed transits of clock stars for the different observers to reduce to the system of Hammond are as follows:

Frederickson	Rines	Wylie	Aston
s	s	s	s
−.007	−.021	+.005	+.005

These values of the relative personal equations are small and moreover there was no evidence of change in the different years.

The resulting values of relative personality from the personal equation machine for stars of 10° declination, corresponding to the mean declination of the clock stars, as derived from the first table are as follows:

Frederickson	Rines	Wylie	Aston
s	s	s	s
−.009	+.004	+.006	−.003

The agreement is good except in the case of Rines, whose absolute personal equation is not based on many determinations. It should be noted also that the relative personal equations as derived from clock corrections are affected by peculiarities in the determination of the instrumental constants.

Magnitude Equation

The instrument is equipped with two screens by means of which the magnitude of all the standard stars observed were reduced to some magnitude between 5.0 and 8.0. It was only necessary therefore to determine the magnitude equation for a range of 3 magnitudes between these limits. This was done with considerable accuracy for 3 observers and the following results obtained:

Magnitude Equation for a Range of 3 Magnitudes Between 5.0 and 8.0 in Sense Bright Minus Faint

Hammond	Frederickson	Wylie
s	s	s
.000	.000	−.001

The magnitude equation with the self-registering micrometer for stars between the 5th and 8th magnitude is negligible.

Corrections to Observations of Standard Stars to Reduce to System Hammond

δ	Frederickson		Rines		Wylie		Aston	
	Clamp East	Clamp West	Clamp East	Clamp West	Clamp East	Clamp West	Clamp East	Clamp West
°	s	s	s	s	s	s	s	s
−25	.000	−.003	−.010	+.008	+.020	−.018	+.015	−.015
−15	+.001	−.002	−.007	+.005	+.015	−.014	+.009	−.010
−5	+.001	−.001	−.004	+.002	+.009	−.010	+.005	−.007
+5	+.001	.000	−.002	−.001	+.003	−.004	+.001	−.002
15	−.001	+.001	−.002	−.002	−.003	+.003	−.001	+.003
25	−.002	+.002	−.002	+.001	−.008	+.008	−.003	+.007
35	−.004	+.004	.000	+.005	−.007	+.014	−.004	+.011
45	−.004	+.004	+.003	+.001	.000	+.021	−.001	+.013
55	−.002	+.007	.000	−.003	+.010	+.033	+.005	+.016
65	.00	+.01	+.01	.00	+.02	+.04	+.02	+.02
75	+.01	+.02	−.02	+.01	+.04	+.04	+.05	+.04
85	+.02	+.08	−.05	+.01	.00	.00	+.15	+.18
95	+.02	+.10	−.01	−.03	−.16	+.07	.....	.....
+105	+.01	+.04	+.02	−.03	−.12	+.07	.....	.....

Comparison of Observations of Standard Stars

All the observations of the standard stars made by any observer were in general reduced with clock corrections and constants determined by himself. From these observations, the differences between the various observers were deduced. In doing this, the two positions of the clamp were kept separate and the comparisons were made in zones 10° wide in declination. These differences, which are small, must be due to peculiarities in the determination of the instrumental constants, combined perhaps with a variation in absolute personal equation with the declination.

The preceding table gives corrections for each observer to reduce to the system Hammond.

The corrections for Frederickson and Rines are small enough to be attributed to accidental errors. In the case of Wylie and Aston, however, the corrections appear to be real but it has not been attempted to represent them by an empirical formula. There was not enough data to determine the corrections in the case of Aston for stars at lower culmination.

There is considerable difference in opinion as to the relative advantages of the hand-driven and motor-driven micrometers. It is quite possible that certain systematic errors may be introduced by the latter which are lacking in the case of the former. It is my opinion that an observer, after a little practice, can follow a star with as little accidental error with a hand-driven micrometer as with a motor-driven one. For an experienced observer, under good conditions of seeing, the probable error of a single contact or registration with the micrometer of the 6-inch transit circle is, $p = \pm 0^s.022 \sec \delta$.

This micrometer has never given any trouble and the simplicity of its construction and operation recommends it for use in fundamental work.

ON DIFFERENTIAL HORIZONTAL REFRACTION,

By WILLIAM B. VARNUM.

On examining the clock corrections for the Albany observations made 1907–18, a well marked term, depending upon the time of day at which the observation was made, developed. It is not the same for all stretches during which the observations were continuous but is very consistent throughout any one stretch. Twenty-one stretches extending from 1915 to 1917 were chosen. These are well distributed as to clamps, observers and months of the year. The means by groups are shown in the following table: —

(1)	(2)	(3)	(4)	(5)
h m		s	s	s
23 44	4	+0.040	+0.017	+0.023
1 22	6	+ .036	+ .025	+ .011
2 2	14	+ .030	+ .013	+ .016
3 2	27	− .007	− .001	− .006
4 1	101	+ .029	+ .015	+ .014
5 0	45	+ .028	+ .027	+ .001
6 2	53	+ .009	+ .006	+ .003
7 5	91	+ .009	+ .007	+ .002
7 59	103	+ .004	+ .002	+ .003
8 58	132	+ .012	+ .012	− .001
10 0	143	+ .014	+ .006	+ .008
10 57	106	+ .017	+ .012	+ .005
11 56	63	+ .008	+ .006	+ .003
12 55	42	+ .011	+ .005	+ .006
14 0	21	+ .009	− .004	+ .013
14 58	24	+0.018	+0.004	+0.014
15 54	8	+ .013	+ .005	+ .008
16 48	10	− .004	+ .008	− .012
18 12	14	− .009	+ .002	− .011
19 4	27	− .011	− .007	− .005
20 0	53	− .039	− .029	− .010
20 57	63	− .005	− .007	+ .002
22 4	41	− .014	− .007	− .008
22 52	18	− .021	− .010	− .011
	1209			

Column (1) = Albany mean time
Column (2) = No. of observations
Column (3) = ΔT − Computed clock correction
Column (4) = Computed value of (3)
Column (5) = (O − C) = (3) − (4)

Believing this phenomenon was due to differential horizontal refraction (dr), (4) was computed from (3) by the formula $\sec \delta \sec (\phi - \delta) M + \sec \delta \sec (\phi - \delta) \times MR$, where M = Mass of the air, R = Rate of change of mass. The lateral refraction will cause a correction to the computed azimuths of the form

$$\Delta a = \sec (\phi - \delta) \operatorname{cosec} (\phi - \delta)\, dr.$$

Hence, the total effect at any declination will be, for Albany, $\sec\ \delta\ [+2.01\ \sin\ (\phi - \delta) + \sec\ (\phi - \delta)] \times (M + MR) = dr$. The values of dr were computed for each stretch and applied. Collecting the computed values we have column (4), and collecting the (O — C) values we have column (5).

The application of these corrections reduced the probable error from $\pm^s.0336$ with a probable error of $\pm^s.0048$ to $\pm^s.0259$ with a probable error of $\pm^s.0031$.

The details of the investigation will appear in a later paper.

Dudley Observatory, Albany, N. Y.,
April 28, 1921.

MEASURES OF DOUBLE STARS,

MADE WITH THE $10\frac{1}{2}$ IN. REFRACTOR OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

These observations follow the measures published in *A. J.*, 749. The double stars are mostly well known binaries. Magnifying power 400. Right ascensions and declinations for 1900.

456 Σ 67 $0^h\ 47^m$ +10° 4′

20.853	0.1	1.95	8.3	8.7	
20.869	0.3	2.12	. .	. .	
20.878	1.1	1.86	8.3	8.6	
1920.87	0.5	1.98	8.3	8.6	3*n*

479 OΣ 20 $0^h\ 49^m$ +18° 39′

19.052	300.3	0.42	6.5	7.5	
19.071	298.0	0.56	6.0	7.0	
19.085	298.3	0.55	6.0	7.5	
1919.07	298.9	0.51	6.2	7.3	3*n*

482 Σ 73 $0^h\ 50^m$ +23° 5′

19.082	47.9	0.77	. .	. .	
19.996	51.4	0.64	6.0	6.2	
20.845	53.8	0.79	6.0	6.2	
20.875	54.4	0.90	. .	. .	
20.930	53.0	0.65	6.0	6.2	
1919.54	49.6	0.70	6.0	6.2	2*n*
1920.88	53.7	0.78	6.0	6.2	3*n*

797 Σ 113 $1^h\ 15^m$ −1° 2′

19.876	359.0	1.42	6.2	6.8	
19.884	359.3	1.31	6.2	6.7	
20.878	358.0	1.61	6.2	7.0	
20.930	360.1	1.73	6.2	6.7	
20.935	360.0	1.59	6.2	6.7	
1919.88	359.2	1.36	6.2	6.8	2*n*
1920.91	359.5	1.64	6.2	6.8	3*n*

830 Σ 138 $1^h\ 31^m$ +7° 8′

20.845	43.8	1.64	. .		
20.930	41.6	1.48	7.1	7.0	
1920.89	42.7	1.56	7.1	7.0	2*n*

1365 OΣ 13 $2^h\ 35^m$ +26° 11′

19.071	34.7	0.97	7.0	9.3	
19.073	37.3	0.99	7.0	9.0	
19.082	35.5	1.04	7.0	9.0	
19.085	34.9	0.94	7.0	8.8	
1919.08	35.6	0.98	7.0	9.0	4*n*

1427 Σ 305 $2^h\ 42^m$ +18° 57′

19.996	313.7	3.12	7.3	7.9	
20.935	313.6	3.09	7.3	7.8	
21.021	315.6	3.04	7.3	7.9	
21.026	314.4	3.17	7.3	8.0	
1920.74	314.3	3.10	7.3	7.9	4*n*

1512 Σ 333 $2^h\ 53^m$ +20° 56′

19.996	204.4	1.38	5.5	6.0	
20.935	202.2	1.66	5.5	6.1	
20.960	204.4	1.35	5.5	6.5	
21.018	204.6	1.46	5.5	6.2	
1920.73	203.9	1.46	5.5	6.2	4*n*

1900 OΣ 65 $3^h\ 44^m$ +25° 17′

21.023	206.4	0.67	. .	. .	
21.058	206.3	0.54	6.4	7.4	
21.064	208.2	0.55	6.4	7.2	
1921.05	207.0	0.59	6.4	7.3	3*n*

2109 Σ 518 $4^h\ 11^m$ −7° 48′

A and *B*

19.071	105.4	82.95	. .	. .	
19.082	105.3	82.71	. .		
19.110	106.0	82.51	. .		
19.134	104.8	82.70	. .		
1919.10	105.4	82.72			4*n*

B and *C*

19.071	16.9	3.40	9.0	11.5	
19.082	15.7	3.54	9.0	11.0	
19.110	17.6	3.27	9.0	11.0	
1919.09	16.7	3.40	9.0	11.2	3*n*

2161 Σ 535 $4^h\ 18^m$ +11° 09′

20.163	317.7	1.32	7.0	8.5	
21.032	321.6	1.52	7.0	8.3	
21.056	320.6	1.76	7.0	8.8	
21.062	320.0	1.69	6.7	8.3	
1920.83	320.0	1.57	6.9	8.5	4*n*

2336 Σ 589 $4^h\ 40^m$ +5° 6′

21.056	294.1	4.48	8.0	8.1	
21.059	294.8	4.45	8.2	8.0	
1921.06	294.4	4.46	8.1	8.1	2*n*

2535 OΣ 98 $5^h\ 2^m$ +8° 22′

20.163	140.5	0.80	6.0	7.3	
20.166	140.3	0.99	6.0	6.8	
20.188	143.1	0.90	6.0	6.8	
1920.17	141.3	0.90	6.0	7.0	3*n*

2706 Wx 2 $5^h\ 19^m$ −0° 59′

20.199	164.8	2.11	6.5	6.7	
21.023	165.0	2.47	6.0	6.2	
21.058	165.8	2.13	6.0	6.3	
1920.76	165.2	2.24	6.2	6.4	3*n*

2712 Da 5 $5^h\ 19^m$ −2° 29′

20.166	79.6	1.31	4.0	5.4	
20.185	81.5	1.38	4.0	5.3	
20.188	80.3	1.25	4.0	5.5	
20.199	79.0	1.32	4.0	5.2	
1920.18	80.1	1.32	4.0	5.4	4*n*

2845 Σ 749 $5^h\ 31^m$ +26° 52′

19.173	165.1	0.98	. .	. .	
19.175	168.2	0.91	. .	. .	
19.184	165.2	0.93	7.0	7.1	
19.189	167.6	0.86	. .	. .	
19.216	168.1	0.87	7.0	7.4	
20.163	167.0	0.96	7.0	7.3	
20.166	167.5	0.98	7.0	7.1	
20.185	169.7	. . . .	. .		
20.188	167.1	0.94	7.1	7.0	
1919.19	166.8	0.91	7.0	7.2	5*n*
1920.18	167.8	0.96	7.0	7.1	4*n*

2902 Σ 774 $5^h 36^m$ $-2° 00'$

20.185	157.0	...	..	.	
20.188	158.2	2.57	2.0	4.5	
20.196	156.3	2.41	.	.	
20.199	157.4	2.61	.		
1920.19	157.2	2.53	2.0	4.5	4-3*n*

Jon 1231 $6^h 21^m$ $+11° 31'$

20.256	39.3	4.43	9.0	9.2	
20.259	38.8	4.98	9.0	9.1	
1920.26	39.0	4.70	9.0	9.2	2*n*

A. G. ... $6^h 23^m$ $+13° 57'$

20.256	289.8	8.14	8.8	10.8	
20.259	289.0	8.35	9.0	11.0	
1920.26	289.4	8.24	8.9	10.9	2*n*

3596 *Sirius* $6^h 41^m$ $-16° 35'$

19.071	68.1	11.20	..	7	
19.082	69.0	10.98	..	7	
19.134	69.1	11.01		.	
19.184	71.0	11.11		8	
19.216	68.1	11.30	.		
19.222	70.0	11.08	.		
19.233	71.5	11.10		7.5	
20.163	67.1	11.18	.	.	
20.166	66.9	11.16	.		
20.188	68.1	11.58	.	.	
20.199	65.6	11.44			
1919.16	69.6	11.11		7.4	7*n*
1920.18	66.9	11.34		..	4*n*

Arg. 65 $7^h 8^m$ $-1° 31'$

19.199	186.4	8.71	9.8	10.0	
19.223	188.8	8.46	9.5	9.7	
1919.21	187.6	8.58	9.6	9.8	2*n*

3949 OΣ 170 $7^h 12^m$ $+9° 29'$

20.155	102.8	1.31	7.5	7.9	
20.163	106.0	1.48	7.5	7.6	
20.166	105.1	1.52	7.5	7.7	
20.188	104.1	1.46	7.5	7.6	
1920.17	104.5	1.44	7.5	7.7	4*n*

4008 Lv 4 $7^h 17^m$ $-19° 32'$

20.166	129.2	....	..	...	
20.199	131.9	1.84	9.0	9.0	
1920.18	130.6	1.84	9.0	9.0	2-1*n*

4122 *Castor* $7^h 28^m$ $+32° 6'$

19.351	215.9	5.01	2.0	3.3	
19.353	215.9	4.77	..	.	
20.185	217.1	4.95	2.0	2.8	
20.242	215.3	4.94	2.0	2.5	
20.284	216.5	4.98	2.0	2.8	
20.286	215.5	4.93	2.0	3.0	
20.289	215.5.	4.98	2.0	3.2	
1919.35	215.9	4.89	2.0	3.3	2*n*
1920.26	216.0	4.95	2.0	2.9	5*n*

4193 Σ 1126 $7^h 35^m$ $+5° 28'$

20.267	149.3	1.06	7.0	7.5	
20.284	150.3	1.15	7.0	7.5	
20.286	149.0	1.11	7.0	7.3	
1920.28	149.5	1.11	7.0	7.4	3*n*

4402 Σ 1175 $7^h 57^m$ $+4° 26'$

20.163	233.9	1.58	8.0	9.3	
20.166	235.5	1.52	8.0	9.0	
20.188	234.5	1.33	8.0	10.0	
20.267	234.4	1.42	8.0	9.5	
1920.20	234.6	1.46	8.0	9.4	4*n*

4477 *ζ Cancri* $8^h 6^m$ $+17° 57'$

A and *B*

19.129	289.8	0.85	.	..	
18.184	286.2	0.79	5.0	5.3	
19.189	285.0	0.73	.	.	
19.233	287.0	0.78	5.0	5.4	
20.163	282.2	0.75	5.0	5.3	
20.166	282.2	0.79	5.0	5.3	
20.185	282.1	0.86	5.0	5.4	
20.188	280.7	0.80	5.0	5.5	
1919.18	287.0	0.79	5.0	5.4	4*n*
1920.18	281.8	0.80	5.0	5.4	4*n*

AB and *C*

19.129	111.1	5.45	.		
19.184	109.7	5.66		5.6	
19.189	110.5	5.53		.	
19.233	111.1	5.43	.	5.7	
20.163	108.6	5.58		5.6	
20.166	108.4	5.56	..	5.6	
20.185	107.9	5.49		5.6	
20.188	108.9	5.62	..	5.7	
1919.18	110.6	5.52	..	5.6	4*n*
1920.18	108.4	5.56		5.6	4*n*

4771 Σ 1273 $8^h 44^m$ $+6° 47'$

AB and *C*

20.185	245.6	2.88	3.5	7.0	
20.188	244.2	3.00	..	..	
20.199	245.8	3.08	3.5	6.0	
20.242	245.3	3.49	..	..	
20.256	244.7	2.81	.		
1920.21	245.1	3.05	3.5	6.5	5*n*

4839 Σ 1294 $8^h 48^m$ $+30° 58'$

20.281	321.0	1.40	..	..	
20.284	322.3	1.52	6.0	6.2	
20.289	324.9	1.38	6.0	6.2	
1920.28	322.7	1.43	6.0	6.2	3*n*

5071 Σ 1348 $9^h 19^m$ $+6° 47'$

20.199	320.9	1.97	7.1	7.0	
20.231	321.7	2.08	7.1	7.0	
1920.22	321.3	2.02	7.1	7.0	2*n*

5103 Σ 1356 $9^h 23^m$ $+9° 30'$

19.350	127.8	1.06	6.0	7.0	
20.199	128.4	0.94	6.0	7.0	
20.234	125.7	0.97	6.0	7.0	
20.256	131.6	0.91	6.0	6.7	
20.259	130.2	1.06	6.0	6.7	
1919.35	127.8	1.06	6.0	7.0	1*n*
1920.24	129.0	0.97	6.0	6.8	4*n*

5365 OΣ 215 $10^h 11^m$ $+18° 14'$

19.351	200.2	0.96	7.0	7.5	
19.403	203.0	0.98	7.0	7.2	
19.405	202.2	0.98	7.0	7.3	
20.234	201.4	0.86	7.0	7.5	
20.259	200.5	1.04	7.0	7.4	
20.267	200.7	0.99	7.0	7.4	
1919.39	201.8	0.97	7.0	7.3	3*n*
1920.25	200.9	0.96	7.0	7.4	3*n*

5388 Σ 1424 $10^h 14^m$ $+20° 21'$

19.403	117.4	3.84	2.0	4.5	
19.405	117.9	3.60	2.0	3.5	
19.424	119.8	3.79	..	.	
19.449	118.3	3.61	..	...	
20.330	118.5	3.77	.	..	
20.338	118.4	3.71	2.0	3.2	
20.368	119.4	3.75	2.0	3.0	
1919.42	118.4	3.71	2.0	4.0	4*n*
1920.34	118.7	3.74	2.0	3.1	3*n*

5734 Σ 1523 $11^h 13^m$ $+32° 6'$

19.405	107.6	2.78	4.0	4.4	
19.449	106.1	2.76	4.0	4.3	
20.368	103.5 *	2.84	4.0	4.4	
20.398	103.3	2.74	4.0	4.7	
20.404	104.0	2.98	4.0	4.3	
20.440	103.6	2.86	.	.	
1919.43	106.8	2.77	4.0	4.4	2*n*
1920.40	103.6	2.86	4.0	4.5	4*n*

5765 Σ 1536 $11^h 19^m$ $-11° 05'$

19.351	38.2	2.15	..	.	
19.383	36.9	1.93	..	..	
19.400	37.3	1.46	4.0	7.5	
19.403	39.0	1.75	4.0	7.0	
19.405	38.2	1.55	4.0	7.5	
20.338	38.2	1.56	..	..	
20.341	36.9	1.70	4.0	7.5	
20.349	36.2	1.84	4.0	7.0	
20.368	38.4	1.84	4.0	7.5	
1919.39	37.9	1.77	4.0	7.3	5*n*
1920.35	37.4	1.72	4.0	7.3	4*n*

6187 Σ 1647 $12^h 25^m$ $+10° 16'$

20.368	229.0	1.31	8.0	8.6	
20.385	227.9	1.19			
20.396	225.9	1.38	8.0	8.5	
1920.38	228.0	1.29	8.0	8.6	3*n*

6243 Σ 1670 $12^h\ 37^m$ $-0°\ 54'$

19.463	324.3	5.48	3.6	3.5	
19.476	322.9	5.82	..	..	
19.479	321.9	5.90	3.5	3.6	
19.482	322.2	5.80	3.5	3.6	
20.404	321.3	5.90	3.5	3.6	
20.420	321.5	5.86	..	..	
20.445	322.2	5.76	3.5	3.8	
1919.48	322.8	5.75	3.5	3.5	4*n*
1920.42	321.7	5.84	3.5	3.7	3*n*

6296 Σ 1687 $12^h\ 48^m$ $+21°\ 47'$

17.441	92.6	1.25	5.0	8.0	
19.501	98.9	1.17	5.0	8.3	
19.509	99.7	1.14	5.0	8.2	
20.341	98.5	1.06	5.0	8.5	
20.349	95.6	1.17	5.0	8.0	
20.398	95.7	1.15	.		
1917.44	92.6	1.25	5.0	8.0	1*n*
1919.50	99.3	1.16	5.0	8.2	2*n*
1920.36	96.6	1.13	5.0	8.2	3*n*

6312 OΣ 256 $12^h\ 51^m$ $-0°\ 25'$

19.383	81.0	0.75	..	.	
19.403	81.1	0.86	7.0	7.2	
19.405	80.6	0.71	..	...	
20.404	82.2	0.86	7.8	7.0	
20.440	78.6	0.80	.	..	
1919.40	80.9	0.77	7.0	7.2	3*n*
1920.42	80.4	0.83	7.8	7.0	2*n*

6367 β 929 $12^h\ 59^m$ $-3°\ 08'$

19.403	210.3	0.59	7.0	7.4	
19.405	212.6	0.67	..	...	
20.404	211.4	0.66	7.0	7.8	
1919.74	211.4	0.64	7.0	7.6	3*n*

6415 OΣ 261 $13^h\ 7^m$ $+32°\ 37'$

20.478	344.2	1.53	7.0	7.3	
20.494	343.6	1.70	7.0	7.2	
1920.49	343.9	1.62	7.0	7.2	2*n*

6566 Σ 1768 $13^h\ 33^m$ $+36°\ 48'$

19.498	120.9	1.77	5.0	8.0	
19.501	124.3	1.56	5.0	7.5	
19.509	124.7	1.62	5.0	7.5	
1919.50	123.3	1.65	5.0	7.7	3*n*

6641 Σ 1785 $13^h\ 45^m$ $+27°\ 29'$

19.400	3.7	1.05	7.0	7.3	
19.424	4.9	1.17	7.0	7.3	
19.463	4.2	1.11	7.0	7.3	
20.399	10.4	1.06	7.0	7.3	
20.420	9.8	1.19	..	..	
20.478	9.8	1.08	7.0	7.2	
1919.43	4.3	1.11	7.0	7.3	3*n*
1920.43	10.0	1.11	7.0	7.2	3*n*

6780 Σ 1819 $14^h\ 10^m$ $+3°\ 35'$

19.400	341.6	1.30	8.0	8.3	
19.463	342.2	1.24	7.5	7.6	
19.479	341.2	1.31	8.0	8.1	
19.496	342.1	1.05	.		
19.498	341.0	1.21	8.0	8.2	
1919.47	341.6	1.22	7.9	8.1	5*n*

6955 Σ 1865 $14^h\ 36^m$ $+14°\ 09'$

19.463	140.7	0.86	40.	4.0	
19.476	140.0	0.78	4.0	4.2	
19.479	141.1	0.88	4.3	4.0	
19.482	138.7	0.81	4.0	4.1	
20.398	138.6	0.88	4.3	4.0	
20.410	136.9	0.94	4.2	4.0	
20.440	138.1	0.82	..	.	
20.445	139.2	0.84	4.1	4.0	
1919.47	140.1	0.83	4.1	4.1	4*n*
1920.43	138.2	0.87	4.2	4.0	4*n*

7034 Σ 1888 $14^h\ 47^m$ $+19°\ 31'$

19.424	73.9	2.44	..	.	
19.448	74.2	2.28	5.0	6.8	
19.462	72.4	2.44	5.0	7.0	
19.476	73.2	2.35	5.0	7.0	
19.498	74.7	2.36	5.0	7.5	
19.512	73.4	2.41	..	..	
20.478	66.9	2.43	5.0	7.5	
20.494	65.3	2.60	5.0	7.5	
1919.47	73.6	2.38	5.0	7.1	6*n*
1920.49	66.1	2.52	5.0	7.5	2*n*

7049 OΣ 288 $14^h\ 49^m$ $+16°\ 07'$

19.463	187.2	1.53	6.5	7.0	
19.476	186.3	1.68	6.5	7.2	
19.479	187.2	1.78	6.5	7.0	
1919.47	186.9	1.66	6.5	7.1	3*n*

7120 Σ 1909 $15^h\ 0^m$ $+48°\ 3'$

19.597	243.8	3.66	5.0	6.0	
19.600	243.0	3.80	5.0	6.0	
19.602	244.4	3.67	5.0	6.5	
1919.60	243.7	3.71	5.0	6.2	3*n*

7214 Σ 1932 $15^h\ 14^m$ $+27°\ 12'$

17.433	9.1	0.69	6.9	6.5	
19.498	11.8	0.66	6.3	6.0	
19.501	10.7	0.61	6.2	6.0	
19.509	12.4	0.62		.	
1917.43	9.1	0.69	6.9	6.5	1*n*
1919.50	11.6	0.63	6.2	6.0	3*n*

7251 Σ 1937 $15^h\ 19^m$ $+30°\ 38'$

19.498	86.6	0.68	5.7	5.5	
19.501	85.2	0.69	5.6	5.5	
19.509	87.8	0.65	5.5	5.8	
19.597	88.5	0.59	..	...	
1919.53	87.0	0.65	5.6	5.6	4*n*

7259 Σ 1938 $15^h\ 21^m$ $+37°\ 42'$

19.597	48.8	1.38	7.0	7.4	
19.600	48.3	1.31	6.6	7.0	
1919.60	48.6	1.34	6.8	7.2	2*n*

7563 Σ 2032 $16^h\ 11^m$ $+34°\ 07'$

A and *B*

19.602	218.4	5.28	5.0	6.3	
19.605	220.1	5.12	..	...	
19.611	219.3	4.96	5.0	6.5	
19.616	218.3	5.09	5.0	6.5	
1919.61	219.0	5.11	5.0	6.4	4*n*

A and *D*

19.602	85.6	66.83	..	9.5	
19.605	84.8	66.96	..	...	
19.611	84.4	67.36	..	...	
1919.61	84.9	67.05	..	9.5	3*n*

7649 Σ 2055 $16^h\ 26^m$ $+2°\ 12'$

19.463	79.9	0.88	4.0	5.7	
19.602	78.4	0.92	4.0	6.5	
19.616	79.7	0.82	4.0	6.0	
1919.56	79.3	0.87	4.0	6.1	3*n*

7717 Σ 2084 $16^h\ 38^m$ $+31°\ 47'$

19.597	89.2	1.64	3.0	6.0	
19.600	88.8	1.64	3.0	6.0	
19.605	91.6	1.80	..	...	
19.611	87.8	1.87	3.0	6.0	
19.616	87.4	1.70	3.0	7.0	
19.622	89.2	....	..	..	
1919.61	89.0	1.73	3.0	6.2	6-5*n*

7783 Σ 2107 $16^h\ 48^m$ $+28°\ 50'$

19.597	28.4	0.67	..	...	
19.602	33.3	0.65	6.5	9.0	
19.605	26.3	0.64	6.5	8.5	
19.616	30.6	0.68	6.5	8.0	
1919.60	29.6	0.66	6.5	8.5	4*n*

7914 Σ 2140 $17^h\ 10^m$ $+14°\ 30'$

19.611	112.5	4.53	3.0	7.0	
19.633	112.3	4.67	3.0	5.5	
19.698	113.3	4.50	3.0	6.0	
1919.65	112.7	4.57	3.0	6.2	3*n*

8162 Σ 2220 $17^h\ 43^m$ $+27°\ 47'$

19.597	245.5	33.46	..	.	
19.600	245.4	33.12	..	..	
19.605	246.3	33.07	..	.	
19.616	245.7	33.03	..	.	
1919.60	245.7	33.17	..		4*n*

8303 Σ 2262 $17^h 58^m$ −8° 11′

19.611	261.1	2.00	5.5	6.0	
19.698	262.5	1.95	5.5	6.0	
1919.65	261.8	1.98	5.5	6.0	2*n*

8340 Σ 2272 $18^h 0^m$ +2° 31′

19.698	134.2	5.32	..	..	
19.717	134.2	5.30	4.0	6.0	
19.728	134.4	5.28	4.0	6.0	
19.797	134.1	5.20	4.0	5.8	
20.686	132.8	5.43	4.0	5.5	
20.768	134.1	5.25	4.0	5.5	
20.853	132.2	5.48	..	..	
20.869	133.8	5.49	4.0	6.0	
1919.74	134.2	5.28	4.0	5.9	4*n*
1920.79	133.2	5.41	4.0	5.7	4*n*

8380 Σ 2281 $18^h 5^m$ +3° 58′

19.602	69.8	0.69	6.0	8.0	
19.605	72.7	0.63	6.0	8.0	
19.633	68.1	0.56	6.0	7.5	
1919.61	70.2	0.63	6.0	7.8	3*n*

8505 β 1252 $18^h 17^m$ −11° 55′

19.597	177.9	....	8.0	9.5	
19.602	176.6	1.45	8.0	9.5	
19.698	177.1	....	8.5	9.5	
1919.63	177.2	1.45	8.2	9.5	3-1*n*

Jon 519 $18^h 18^m$ −14° 39′

19.717	155.2	5.82	9.5	11.0	
19.728	157.6	5.11	9.5	11.5	
19.737	161.2	5.65	9.8	11.5	
1919.73	158.0	5.53	9.6	11.3	3*n*

8569 β 1326 $18^h 23^m$ +26° 24′

A and *C*

19.597	61.1	62.41	..	...	
19.602	60.2	61.93	7.0	9.0	
1919.60	60.6	62.17	7.0	9.0	2*n*

8663 OΣ 358 $18^h 32^m$ +16° 54′

19.597	186.5	2.28	7.0	7.4	
19.600	185.4	2.03	7.0	7.3	
19.602	186.7	1.90	7.0	7.2	
1919.60	186.2	2.07	7.0	7.3	3*n*

8798 Σ 2398 $18^h 42^m$ +59° 26′

A and *B*

20.815	154.2	16.70	8.0	8.5	
20.826	153.6	16.94	8.0	8.7	
20.828	154.3	16.90	8.3	8.8	
20.839	154.0	17.00	8.2	8.8	
20.853	152.8	16.78	7.8	8.3	
1920.83	153.8	16.86	8.1	8.6	5*n*

A and *C*

20.815	203.5	58.22	..	11.5	
20.826	203.8	58.98	..	11.5	
20.828	203.4	59.14		11.2	
20.853	203.3	58.98		11.0	
1920.83	203.5	58.83	.	11.3	4*n*

8933 β 648 $18^h 53^m$ +32° 46′

19.630	44.7	1.09	6.0	9.3	
19.698	45.4	1.25	..	..	
19.717	47.0	1.27	6.0	8.5	
19.728	48.0	1.06	6.0	8.0	
19.767	47.2	0.96	6.0	8.5	
20.686	47.1	0.99	6.0	8.0	
20.752	45.2	1.11	6.0	8.0	
20.760	41.0	0.87	6.0	8.0	
20.763	43.1	0.92	6.0	8.0	
20.765	42.9	1.05	..	.	
20.853	40.6	1.10		.	
1919.71	46.5	1.13	6.0	8.6	5*n*
1920.76	43.8	1.01	6.0	8.0	6*n*

9114 Se 2 $19^h 8^m$ +38° 37′

A and *BC*

19.630	217.2	4.14	..	..	
19.717	217.4	4.29	8.2	8.0	
19.797	216.3	4.27	.	...	
20.760	216.0	4.31	..	..	
20.765	217.8	4.19	8.0	7.7	
20.768	216.5	4.26	..	..	
1919.71	217.0	4.23	8.2	8.0	3*n*
1920.76	216.8	4.25	8.0	7.7	3*n*

B and *C*

19.602	100.5	0.69	8.0	8.3	
19.630	92.8	0.63	..	...	
19.717	95.1	0.62	..	.	
19.797	97.0	0.45	8.0	8.0	
20.752	93.0	0.53	8.0	8.0	
20.878	92.4	0.52	8.0	8.7	
1919.69	96.1	0.60	8.0	8.2	4*n*
1920.82	92.7	0.52	8.0	8.4	2*n*

9319 Σ 2525 $19^h 23^m$ +27° 7′

19.630	304.2	1.00	7.5	7.6	
19.717	303.6	0.87	7.5	7.6	
19.728	304.7	1.11	..	..	
19.797	304.2	0.99	7.5	7.8	
20.648	302.8	0.89	..	...	
20.686	305.7	0.97	7.5	8.2	
20.760	307.0	0.96	..	..	
20.812	304.6	0.91	..	.	
1919.72	304.2	0.99	7.5	7.7	4*n*
1920.73	305.0	0.93	7.5	8.2	4*n*

9605 Σ 2579 $19^h 42^m$ +44° 53′

20.752	278.2	2.01	3.0	7.0	
20.806	280.6	2.24	3.0	8.0	
20.826	277.2	1.76	3.0	8.0	
20.828	276.5	2.02	.	...	
20.839	277.0	2.00	3.0	8.0	
20.856	277.2	2.09	..	.	
1920.82	277.8	2.02	3.0	7.8	6*n*

9650 OΣ 387 $19^h 45^m$ +35° 3′

19.630	309.4	0.59	7.0	7.6	
19.764	314.5	0.66	7.0	7.5	
19.797	308.1	0.62	7.0	8.0	
20.806	309.7	0.61	..	..	
20.839	300.2	0.64	7.0	7.5	
20.869	302.4	0.60	7.0	8.0	
20.875	305.7	0.71	7.0	7.8	
1919.73	310.7	0.62	7.0	7.7	3*n*
1920.85	304.5	0.64	7.0	7.8	4*n*

9979 OΣ 400 $20^h 7^m$ +43° 38′

19.630	334.5	0.61	7.0	7.5	
20.875	337.2	0.69	7.0	7.6	
1920.25	335.8	0.65	7.0	7.6	2*n*

10072 β 984 $20^h 13^m$ +26° 4′

20.869	218.2	0.75	8.0	8.5	
20.875	215.8	0.85	8.0	8.4	
1920.87	217.0	0.80	8.0	8.1	2*n*

10076 β 441 $20^h 14^m$ +28° 50′

19.763	64.5	5.71	7.0	11.5	
19.766	66.0	5.86	7.0	11.5	
19.826	65.0	...	7.0	11.5	
1919.78	65.2	5.78	7.0	11.5	3*n*

10533 OΣ 413 $20^h 44^m$ +36° 7′

19.630	46.8	0.65	5.0	6.5	
19.756	44.6	0.55	5.0	5.8	
19.791	43.0	0.60	5.0	5.8	
19.797	49.1	0.56	5.0	6.5	
20.752	42.5	0.72	5.0	6.0	
20.806	45.3	...	..	..	
20.839	45.2	0.58	5.0	6.0	
20.875	46.7	0.73	5.0	5.8	
1919.74	45.9	0.59	5.0	6.2	4*n*
1920.82	44.9	0.68	5.0	5.9	4-3*n*

10732 61 *Cygni* $21^h 2^m$ +38° 15′

20.828	131.0	24.20	5.3	5.8	
20.839	131.3	24.20	..	..	
20.916	131.4	24.18	5.3	6.5	
1920.87	131.2	24.19	5.3	6.2	3*n*

10846 A. G. Clark 13 $21^h\ 11^m$ $+37°\ 37'$

18.736	193.2	1.08	4.0	7.0	
19.630	189.4	1.16	4.0	6.5	
19.696	190.9	0.93	4.0	6.5	
19.791	184.2	1.13	4.0	8.0	
20.875	182.9	1.13	4.0	7.0	
20.935	182.3	1.19	4.0	6.7	
1918.74	193.2	1.08	4.0	7.0	1*n*
1919.71	188.2	1.07	4.0	7.0	3*n*
1920.90	182.6	1.16	4.0	6.8	2*n*

11214 Σ 2822 $21^h\ 40^m$ $+28°\ 17'$

19.696	136.7	1.48	5.0	6.0	
19.717	137.6	1.64	5.0	6.8	
19.797	136.6	1.46	5.0	6.5	
20.749	135.5	1.25	5.0	6.5	
20.763	138.8	1.25	5.0	6.0	
20.812	139.2	1.52	5.0	6.0	
20.826	138.4	1.44	5.0	6.3	
1919.74	137.0	1.53	5.0	6.4	3*n*
1920.79	138.0	1.37	5.0	6.2	4*n*

11743 Σ 2909 $22^h\ 24^m$ $-0°\ 32'$

19.824	305.2	2.74	4.0	4.5	
19.876	304.9	2.75	4.0	4.3	
19.881	305.3	2.76	4.0	4.2	
19.884	304.4	2.63	4.0	4.3	
20.845	305.0	2.79	4.0	4.2	
20.930	303.7	2.77	4.0	4.1	
20.935	303.2	2.74	4.0	4.1	
1919.87	304.9	2.72	4.0	4.3	4*n*
1920.90	304.0	2.77	4.0	4.1	3*n*

12094 OΣ 483 $22^h\ 54^m$ $+11°\ 12'$

19.696	[illegible]	0.79	6.0	7.5	
19.876	238.8	0.80	6.0	7.5	
20.763	243.1	0.86	6.0	7.5	
20.826	240.2	0.75	6.0	7.8	
20.845	237.6	0.86	6.0	7.5	
20.853	243.9	. .	. .		
20.875	240.0	1.02	6.0	7.5	
1919.79	[illegible]	0.80	6.0	7.5	2*n*
1920.83	241.0	0.87	6.0	7.6	5-4*n*

12675 Σ 3050 $23^h\ 54^m$ $+33°\ 10'$

19.865	225.9	2.02	..	...	
19.876	226.3	1.88	6.5	6.9	
19.895	226.0	1.89	6.5	6.9	
1919.88	226.1	1.93	6.5	6.9	3*n*

Minneapolis, Minn.,
March 9, 1921.

EPHEMERIS OF THE *PONS-WINNECKE* COMET,

By F. E. SEAGRAVE.

1921 Greenwich Midnight	α h m	δ ° ′	Log ν	Log Δ
May 20	18 55	+46 14	0.02966	9.30319
24	19 38	+44 25	0.02308	9.24993
28	20 30	+41 20	0.01656	9.19686
June 1	21 22	+35 6	0.01212	9.15448
5	22 9	+25 50	0.00988	9.13145
9	22 55	+15 32	0.00794	9.13225
13	23 33	+ 5 23	0.00732	9.15800
17	0 5	− 3 23	0.00804	9.20108
21	0 29	−10 23	0.01006	9.25190

The above ephemeris is based upon the following elements by Mr. Crawford and Miss Levy: —

$$T = 1921 \text{ June } 13.45 \text{ G. M. T.}$$
$$\omega = 176°\ 32'$$
$$\pi = 270°\ 4'$$
$$\Omega = 93°\ 32'$$
$$i = 19°\ 7'$$
$$\text{Log } e = 9.83594$$
$$\text{Log } a = 0.50956$$
$$\mu = 610''.47$$
$$q = 1.017$$

A CORRECTION,

By H. R. MORGAN.

[Communicated by Superintendent, U. S. Naval Observatory.]

Mr. R. T. A. Innes has kindly called my attention to the fact that the proper-motions of the stars as given in the catalogs are independent of the aberration due to the motion of the solar system in space. The conclusions as to proper-motions in my article in the *Astronomical Journal* No. 774, p. 42, are therefore erroneous. The heading $d\ (\Delta\alpha \cos\delta)$ in Table II should be $(d\ \Delta\alpha) \cos\delta$.

CONTENTS.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors, E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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ON THE DETERMINATION OF DOUBLE STAR ORBITS FROM INCOMPLETE DATA. SECOND PAPER, WITH AN APPLICATION TO THE ORBIT OF γ *CORONAE BOREALIS*, *BU.* 7368.

BY GEORGE C. COMSTOCK.

Under ordinary circumstances the measured position angles of a double star contribute more effectively to the determination of its orbit than do the measured distances, but with increasing inclination of the orbit plane the distances gain considerably in relative value and a special method of utilizing them in such cases is developed in what follows.

Let r' and v denote the radius vector and true anomaly of any point in the perimeter of an ellipse and let r'' and $180° + v$ be the corresponding coördinates of the opposite extremity of the focal chord drawn from the assumed point. These several coördinates are connected with the latus rectum, p, and eccentricity, ϵ, of the ellipse by the relations:

$$\frac{1}{r'} = \frac{1}{p}(1 + \epsilon \cos v) \qquad \frac{1}{r''} = \frac{1}{p}(1 - \epsilon \cos v)$$

By addition and subtraction these relations become

$$\frac{r'' + r'}{2r'r''} = \frac{1}{p} \qquad \frac{r'' - r'}{2r'r''} = \frac{\epsilon}{p}\cos v \tag{1}$$

Let b denote the angle between r' and its projection s' in the apparent orbit of a star, then will $s' = r' \cos b$, $s'' = r'' \cos b$ and eliminating r' r'' from Eq. 1 by means of these relations we obtain for the apparent orbit

$$\frac{2s's''}{s''+s'} = p \cos b = z \qquad \frac{s'' - s'}{s'' + s'} = \epsilon \cos v = \zeta \tag{2}$$

where the symbols z and ζ are introduced as abbreviations for the functions of s', s'' which they respectively equal.

In practice the observed position angles and distances, θ, s, should be independently plotted as ordinates to the time as abscissa and smooth curves so drawn through the plotted data as to satisfy the *a priori* condition $s^2 d\theta / dt = c$, a constant. The results of this graphical adjustment of the data will be hereafter designated the θ-curve and the s-curve. For any assumed date, T, we may read from these curves values of θ and s' and with the argument $\theta + 180°$ find a value of s'' connected with s' through Eq. 2. The z and ζ computed from s', s'' are clearly functions of T and their values, corresponding to the entire range of available data, should be plotted with T as abscissa. Smooth curves drawn through these plotted points will be called the z-curve and the ζ-curve. From Eq. 2 we obtain the following properties of these curves.

THE ζ-CURVE

Within one complete revolution of the star in its orbit the ζ-Curve should present one maximum value, G, corresponding to $v = 0°$ and one numerically equal and negative minimum, $-G$, corresponding to $v = 180°$. The times corresponding to these values are given immediately by the curve and will be called T_0, T_1. With these values of T we may obtain from the θ-curve the corresponding position angles, which should differ by 180°, and each of which will be designated F, with the understanding that 180° is to be added to the value corresponding to negative values of ζ. The points at which the ζ-curve cuts the axis of abscissas, $\zeta = 0$, evidently correspond to $v = \pm 90°$ and the corresponding times and position angles will be represented by T_2, T_6, H, with an understanding similar to the above that the two values obtained for H should differ by 180°.

These several quantities are related to the orbit of the star as follows:

$$
\begin{aligned}
\pm G &= \text{Eccentricity of the orbit} = e \\
T_1 &= \text{Time of periastron passage} = T \\
T_4 &= \text{Time of apastron passage} \qquad\qquad (3) \\
\Gamma &= \text{Position angle of the projected major axis} \\
\Pi &= \text{Position angle of the projected latus-rectum and minor axis.}
\end{aligned}
$$

When the star passes through either extremity of the minor axis we have $\pm v = 90° + \varphi$ where φ denotes the angle of eccentricity defined by the relation $\sin \varphi = e$. For these epochs $\zeta = -e^2$ and we find upon the curve two points for which $\zeta = G^2$ and represent the corresponding times of transit over the minor axis by T_3, T_5 respectively. It is evident that the time of periastron passage is equal to the mean of the times of transit through the extremities of the latus rectum or the extremities of the minor axis,

$$2T = T_2 + T_6 = T_3 + T_5, \tag{4}$$

and more generally T (or T_1) equals the mean of the times corresponding to any two equal values of ζ, *i. e.*, the points of intersection of the ζ-curve with any line parallel to the T-axis. Through this relation there may be made an indefinite number of determinations of T whose agreement *inter se* will serve as a control upon the accuracy with which the curve has been drawn.

From the several values T_1, T_2, ... T_6 above found, the periodic time in the orbit may be obtained through a variety of combinations the simplest of which is

$$P = 2(T_4 - T_1).$$

Other relations are

$$P/2\pi = (T_3 - T_5)/(\pi - 2G), \tag{5}$$

and

$$A_1 P = T_2 - T_6, \qquad \text{etc.}$$

where A_1 is a function of e given in Table I, *Astr. Jour.*, No. 785.

The z-Curve

The angle b contained in Eq. 2 must always lie between the limits $\pm i$, (inclination of the orbit plane), and within the period P it will twice pass through each of the values, $b = 0$, $b = i$, and corresponding to these values the curve must present two equal maxima, D, and two equal minima, d. Corresponding to these ordinates we find, as above, pairs of position angles Δ, δ, that should differ by 180° within each pair. These quantities are related to the real orbit as follows:

$$
\begin{aligned}
D &= \text{Semi-latus-rectum} = p \\
d &= \qquad\qquad = p \cos i \qquad\qquad (6) \\
\Delta &= \text{Position angle of the node} = \Omega \\
\delta &= \qquad\qquad = \Omega \pm 90°
\end{aligned}
$$

In terms of the quantities above defined we may now determine a relation between the three curves, θ, ζ, z, that will serve as a drastic control upon their construction and upon the constants above found from them. Putting $d\theta/dT = \theta'$ $d\zeta/dT = \zeta'$ we find from the respective curves the values of these quantities corresponding to $\zeta = 0$, *i. e.* the slope of each curve for the time at which the ζ-curve cuts the axis of abscissas. Representing by c twice the areal velocity in the apparent orbit we readily find from the relation

$$c = s^2\theta' = r^2 \cos i \, dr/dT$$

the following control equation (for $\zeta = 0$) where z_0 is the ordinate of the z-curve at the time when $\zeta = 0$:

$$\pm 57.3\, D\, d\, \zeta' = G z_0^2 \theta' = \text{a constant.} \tag{7}$$

Since the coefficient of ζ' contains only constant factors the two values of ζ' must be equal *i. e.* the ζ-curve must make equal angles with the time axis at its two points of intersection. More generally the ζ-curve is symmetrical with respect to its maximum and minimum ordinates and this characteristic may be utilized in constructing it from scanty data.

Eq. 7 being satisfied we may find the remaining element of the orbit, λ, the angle from node to periastron measured in the direction of increasing θ as follows: From the right angled spherical triangle in which the angle of inclination, i, is included between the hypotheneuse, λ, and the side, $\Gamma - \Delta$, we obtain,

$$
\begin{aligned}
d \sin \lambda &= z_0 \sin (\Gamma - \Delta) \\
D \cos \lambda &= z_0 \cos (\Gamma - \Delta)
\end{aligned}
$$

Since the coefficients in these equations are all positive numbers λ must lie in the same quandrant with $\Gamma - \Delta$ and its value is conveniently found from

$$d \tan \lambda = D \tan (\Gamma - \Delta) \tag{8}$$

A final control upon much of what precedes may be

had by determining the inclination, i, from the angle X included between the projected major and minor axes of the orbit. *Astr. Jour.* No. 785. Adapting the equations there given to the present notation we have,

$$\tan\psi = \sin 2\lambda \tan(\Gamma - \mathrm{H}) \qquad (9)$$
$$\tan i = \sec(45^\circ + \psi/2)\sqrt{\sin\psi}$$

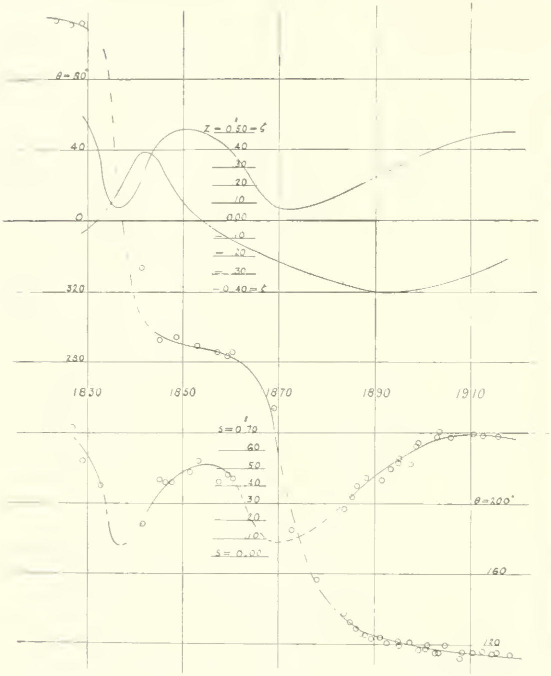
As above noted there are two values for both Γ and H and from these that pair is to be chosen that will place Γ − H in the first quadrant. Compare the value of i here found with that to be obtained from Eq. 6.

The equations 3 to 9 inclusive suffice for multiple determination and control of all the elements of the true orbit without necessity for constructing the apparent orbit. It may be well, nevertheless, to draw this orbit in order to impose upon the data the condition that the star's apparent path must be an ellipse, and to adjust the observed data to meet this requirement. But it is by no means necessary to make this construction since the *a priori* conditions above developed to which the z- and ζ-curves are subject are derived from the assumption of elliptic motion and in themselves they furnish a convenient method of adjusting the data to that condition.

For an application of the methods above set forth I select the binary star γ *Coronae Borealis* whose very narrow apparent orbit imposes upon the computer the obligation to make large use of the measured distances. From the material collected by Lewis, *Mem. R. A. S.*, Vol. LVI, supplemented by the more recent observations of Aitken, Van Biesbroeck and Comstock, I have constructed for the equinox of 1900 normal places, as indicated in Table I, *infra*. The first two columns of this table show the observers and the total number of individual results entering into each normal place. From this data I have constructed to scale $100^c = 160^{mm} = 1''$, the z- and ζ-curves shown, reduced about 4-fold, in Plate A. Broken lines here indicate that in the absence of observed data certain parts of these curves are of necessity drawn by inference. The degree of approximation to which the condition of constant areal velocity has been realized is shown in the second column of Table II where the value of c, as read from the curves, is given at five year intervals. The simple mean of the numbers here tabulated gives $c = 0.157$ as the value of this constant when s is expressed in seconds of arc and θ in degrees per annum. The values of c printed in italics correspond to dates for which adequate observations are not available. They can contribute little to a determination of the areal velocity and I adopt therefore as a definitive value of c the

Table I

Obs'r	n	Epoch	θ	s
Σ .	2	1826.75	110.8	0.73″
Σ .	3	28.98	110.4	.54
Σ	3	32.76	101.0	.40
. .		Single		
Ma.	11	41.50	333.0	.18
Ma. OΣ Daw. .	19	43.22	287.8	.41
Ma.	18	45.17	292.4	.44
Ma. OΣ. Bond .	34	47.89	293.6	.42
OΣ	14	51.40	288.3	.48
Ma. Daw. Jacob	18	53.19	289.0	.54
Ma. OΣ. Daw. Sec.	24	57.24	285.4	.42
OΣ Daw. .	6	59.16	283.4	.46
OΣ .	16	60.35	285.8	.44
OΣ Engl. . .	4	67.41	267.2	.30
OΣ Hall Sp. . . .		Single	.	. .
OΣ	4	1878.07	157.0	.50
Hall, β . .	7	Single	. . .	.
Sp. Engl. Perr. .	16	83.66	138.1	.27
Sp. . . .	12	85.04	133.4	.34
Sp. HΣ . . .	9	86.39	128.3	.40
Sp.	13	87.51	126.5	.38
Sp. HΣ	25	88.32	125.2	.45
Sp. HΣ	10	89.80	123.4	.45
Sp. HΣ Hall	12	91.53	123.7	.43
Bigour. Com. . . .	7	92.74	120.5	.48
Sp.	11	93.30	121.3	.50
Com. HΣ. Barn. Sec.	19	95.21	119.0	.56
Com.	10	97.56	121.1	.52
Ait. Dob. Hus. Lewis	16	97.79	118.7	.62
Ait. Com.	10	98.98	119.2	.64
Ait. Dob. Bry. Lew. Seab. . . .	19	1900.72	117.0	.61
Ait. Com.	10	01.20	120.0	.62
Ait. Bry. W.B. . .	7	02.08	117.4	.55
Ait. Com.	11	02.92	115.0	.67
Bry. Biesb. W.B. Doo.	20	03.42	116.9	.71
W. B. Lewis	4	04.93	119.4	.60
Ait. Com.	10	05.66	117.5	.67
Com. Biesb. .	13	08.30	115.1	.63
Doo.	8	08.39	112.0	.53
Com. Biesb. .	13	10.57	114.8	.69
Ait. Com. Biesb.	11	12.72	115.5	.68
Com. Biesb.	12	15.48	114.8	.68
Com.	9	18.43	114.0	.63



mean of the values printed in Roman type, *viz.*, $c=0.158$. The agreement of this value with the one first found may be regarded as evidence that in the mean the parts of the θ- and s-curves drawn by inference are in substantial agreement with the observed data.

From these curves I read the values of θ and s' shown in the third and fourth columns of Table II and with the argument $\theta+180°$ I find the values of s'' shown in the fifth column of the same table. The quantities ζ and z shown in the following two columns of the table were read from a slide rule under the form,

$$\zeta : 1 = s''-s' : s''+s' \qquad z : s' = 2s'' : s''+s'.$$

These values of ζ and z were so plotted on the same sheet and to the same scale with the θ- and s-curves, see Plate A, that the characteristics of any one of the curves are immediately comparable with those of any other. The elements of the orbit of γ *Coronae* are now furnished by these curves almost at sight, *e. g.*

Table II

Epoch	$s^2\theta'$	θ	s'	s''	ζ	z
		°	″	″		″
1830	*0.16*	109	0.58	0.48	−0.09	0.53
35	*.13*	76	.08	.11	+ .16	.09
40	*.15*	321	.12	.22	.31	.15
45	*.16*	295	.36	.67	.31	.47
50	.16	290	.46	.56	+ .10	.50
55	.16	287	.52	.50	− .02	.48
60	.17	283	.46	.39	.08	.42
65	*.15*	271	.16	.23	.18	.19
70	*.16*	230	.08	.05	.23	.06
75	*.16*	174	.13	.08	.24	.10
80	.16	144	.22	.11	.34	.15
85	.16	131	.33	.16	.35	.15
90	.16	125	.43	.18	.41	.21
95	.16	121	.52	.25	.36	.35
1900	.14	118	.62	.29	.36	.39
05	.16	117	.67	.30	.35	.41
10	.16	115	.67	.36	.30	.47
15	.16	113	.66	.40	− .25	.50
Mean	0.158					

Ephemeris

T	θ		s	
	°		″	
1908.0	115.6	0.6	0.72	0
10.	115.0	.7	.72	1
12.	114.3	.7	.73	0
14.	113.6	.7	.73	0
16.	112.9	.7	.73	1
18.	112.2	.6	.72	2
20.	111.6	.8	.70	3
22.	110.8	.8	.67	3
24.	110.0	1.0	.64	5
26.	109.0	1.1	.59	5
28.	107.9	1.2	.54	6
30.	106.7	1.9	.48	8
32.	104.8	3.0	.40	8
34.	101.8	4.5	.32	10
36.	97.3	13.2	.22	10
38.	84.1	68.	.12	7
40.	16.	63.	.05	8
42.0	313.		.13	

FROM THE ζ-CURVE

$\zeta = \begin{cases} \text{Maximum} \\ \text{and} \\ \text{Minimum} \end{cases}$	$G = 0.40$,	0.40	Eccentricity = 0.40
	$\Gamma = 301°$,	123°	Periastron, $\theta = 122°$
	$T = 1842$,	1892	Periodic Time = 100 years
$\zeta = 0$	$\Pi = 102°$,	288°	Minor Axis $\theta = 105°$
	$T = 1831.6$,	1854.1	Periastron, $T = 1842.8$
$\zeta = -G^2$	$T = 1864$	...	Minor Axis, $T = 1864$

FROM THE z-CURVE

z = Maxima	$D = 0.51$	0.51	$p = 0''.51 = a \cos^2 \varphi$
	$\Delta = 111°$		$\Omega = 111°$
z = Minima	$d = 0.07$	0.07	$p \cos i = 0.07$
	$\delta = 24°$	200°	$\Omega = 114°$ and 110°

These quantities are for the most part to be regarded as only illustrative of the properties of the curves. Before attempting to utilize them further, recourse should be had to the check relation, Eq. 7, as shown in the following schedule

FOR $\zeta = 0$

T	1832	1854
z_0	0.46	0.50
θ'	5.6	0.50
ζ'	0.023	0.023
$\pm 57.3 D d \zeta'$	0.046	0.047
$G z_0^2 \theta'$	.047	.046

The agreement shown in the last two lines of the schedule constitutes a satisfactory control upon the values of the constants G, D, d and upon the substantial accuracy of the θ, ζ and z-curves in the region adjacent to periastron, *i.e.*, in the parts drawn by inference.

We may now proceed as follows to a more precise determination of the elements of the orbit beginning with the time of periastron passage. From the ζ-curve we find for selected pairs of equal values of ζ, the times, T, shown in the following schedule, where the positive values of ζ relate to periastron and the negative to apastron passage.

PERIASTRON

ζ	T'	T''	T
0.00	1831.6	1854.1	1842.8
+ .05	33.8	51.6	42.7
.10	35.2	50.0	42.6
.15	36.2	49.1	42.6
.20	37.1	47.8	42.5
.25	38.2	46.8	42.5
+ .30	39.5	45.6	42.5
Max.	....	....	42.4
		Mean	1842.6

APASTRON

ζ	T'	T''	T
−0.25	1872.6	1914.1	1893.4
.30	77.1	10.2	93.6
− .35	82.7	04.3	93.5
Min.	.	...	93. (?)
		Mean	1893.5

These mean values may be adopted as definitive and from their difference we find

$$P = 2(1893.5 - 1842.6) = 101.8 \text{ years.}$$

Another and possibly better value of P may be found from the circumstance that within the period covered by observation the star has nearly completed a revolution in its orbit. Thus from the θ-curve

$$\begin{array}{ll} \text{For } 1830.0 & \theta = 109.° \\ \phantom{\text{For }} 1915.0 & = 114.5 \\ \hline \phantom{\text{For }} 85.0 \text{ years} & = 354°.5 \text{ motion.} \end{array}$$

The time ΔP required for the remaining $\Delta\theta = 5°.5$ of orbital motion is obviously equal to $\Delta\theta$ divided by a

mean value of $\theta' - c\ s^2$. From the s-curve it is apparent that the mean value of s during this period cannot differ much from $0''.66$ or $0''.67$ and with this value and $c = 0.158$ I find $\Delta P = +15.4$, $P = 100.4$ years. I adopt as a weighted mean result, $P = 101.0$ years. Applying one-half of this value to the time of apastron passage above found we obtain a new value, $T = 1843.0$, for comparison with the time of periastron passage directly determined from the positive values of ζ. I adopt $T = 1842.7$.

These results enable us to obtain a new determination of the eccentricity, e, by comparison of the periodic time with the time required to pass from $v = -90°$ to $v = +90°$, *i. e.*

$$A_1 = (1854.1 - 1831.6) \div 101.0 = 0.223, \quad e = 0.45$$

The disparity between this value and the one above found from the ordinates of the ζ-curve, $e = 0.40$, could be removed by slight modifications of the curves, corresponding to amendment of the STRUVE observations, 1826 — 1832, by amounts of the order of $0''.1$. I have preferred not to do this, and allowing the disparity to stand I adopt as a mean result, $e = 0.42$.

Three values have above been found for the position angle of the node but two of these, derived from δ, are of relatively small weight since they depend upon parts of the curves where small errors of position are greatly magnified in the results read from them. On the other hand it is apparent that a maximum of the z-curve lies just outside the range of observation *i. e.* between position angles 110° and 113° and we may regard these numbers as a confirmation of the value found from the observed maximum of z. I adopt this value, *viz.* $\Omega = 111°$.

From the values of D and d I derive, Eq. 6,

$$p = 0''.51, \qquad a = 0''.62, \qquad i = 82°.1,$$

and from Eq. 7,

$$\lambda = 234°.8.$$

As a control upon these values we find through Eq. 9, $\Gamma - \Pi = 17°$, $\psi = 73°.9$, $i = 81°.9$. The confirmation seems adequate and I adopt $i = 82°.0$.

Collecting the results above obtained and dropping superfluous digits we find as the elements of the orbit of γ *Coronae Borealis*

$$\begin{aligned} P &= 101^{\circ}.\ \text{years} \\ T &= 1842.7 \\ \Omega &= 111°. \\ i &= \ \ 82\ . \\ \lambda &= 235\ . \\ e &= 0.42 \\ a &= 0''.62 \\ n &= -3°.564 \end{aligned} \quad \left.\begin{matrix}\Omega\\ i\\ \lambda\end{matrix}\right\} 1900.0$$

Of these elements T, λ, i, Ω, and a appear well determined. The uncertainty in e is probably of the order 0.02 and in P, 2, 3, or possibly 4 years. The elements in general differ but little from the mean of those hitherto found and collected by LEWIS, *loc. cit.*, but a considerable body of modern observations now controls and in part supplants the early observations of STRUVE which have hitherto had a dominant influence upon a and P. As a result of this recent data the periodic time becomes greater and the semi-axis-major smaller than any values hitherto determined.

I append to this paper a brief ephemeris of γ *Coronae* computed from the foregoing elements. A comparison of this ephemeris with the earliest and latest observations available brings into evidence the systematic differences between the observations of STRUVE and the later observers made at approximately the same part of the orbit, *viz.*, $\theta = 104°$ to 115°.

OBSERVATION — EPHEMERIS

Obs'r	Nights	Epoch	O — C θ	O — C s
			°	"
Σ	2	1826.75	+2.3	+0.18
Σ	3	28.98	+3.4	+ .06
Σ	3	32.76	+1.2	+ .07
AIT. BIES. COM.	11	1912.72	+1.5	− .05
BIES. COM.	12	15.48	+1.7	− .05
COM.	9	18.43	+1.9	− .09

It is this systematic difference in s that is the chief cause of uncertainty in the present orbit.

Washburn Observatory,
March, 1921.

A FAINT STAR OF CONSIDERABLE PROPER-MOTION,

BY H. L. ALDEN.

The annual proper-motion in right ascension of γ *Hydrae*, R. A. 13ʰ 13ᵐ, Decl. −22° 38′ (1900), derived from the McCormick parallax plates by C. P. OLIVIER is $+0''.176$ as given in the *Publications of the Leander*

McCormick Observatory 3, 325. The corresponding value from the *Preliminary General Catalog* of Boss is +0″.067, the proper-motion in declination being −0″.051. As the probable error of the McCormick value of the proper-motion derived from the least square solution is ±0″.0065 the difference is real and must be due to motion of one or more of the three comparison stars used in the original solution.

To detect this motion two pairs of plates were measured, the first pair separated by an interval of four years and the second by three years. Measures were made in both right ascension and declination and in the direct and reversed positions of the plate. Each plate contained two exposures of sufficient length to show all the stars in the *B. D.* Nine stars including γ *Hydrae* were measured on the first pair of plates and ten on the second pair.

A preliminary solution showed that the second comparison star used by OLIVIER had a motion in right ascension of the order of a third of a second of arc per year. This star is *B. D.* −22 3557, the position for 1855 being R. A. $13^h 11^m 23^s.4$, Decl. −22° 15′.3 and the magnitude 9.4.

Omitting this star and γ *Hydrae*, plate constants were computed using first order terms only. The proper-motion of the *B. D.* star derived from the two pairs of plates is as follows: —

Plates	Interval Years	Annual R. A.	Proper-motion Decl.
1358 — 7217	4.04	−0″.356	−0″.029
1081 — 5163	2.96	−0″.375	−0″.045

The weighted mean gives for the motion in right ascension −0″.364 or $-0^s.0263$ and in declination −0″.036. The total motion is 0″.366 in 264°.4.

This star is found in the *Cape Photographic Durchmusterung* but the position is not sufficiently accurate to permit a reliable determination of the proper-motion by comparison with this catalog. It is not found in the *Cordoba Catalog*, Vol. XXII.

In the solution for the parallax of γ *Hydrae* this star had a dependence of 0.3156. Multiplying the motion of this star in right ascension by this dependence and correcting the observed motion of γ *Hydrae*, the resulting value is −0″.061, in good agreement with Boss. The proper-motion of γ *Hydrae* was also obtained from the present measures but with considerable uncertainty because of the large size of the image on the earlier plates. The results are: —

Plates	Interval Years	Annual R. A.	Proper-motion Decl.
1358 — 7217	4.04	+0″.071	−0″.014
1081 — 5163	2.96	+0″.049	−0″.096

The weighted means give in right ascension +0″.062 and in declination −0″.049. These values also agree with those of Boss.

The parallax of +0″.007 obtained by OLIVIER for γ *Hydrae* is relative to the mean parallax of the comparison stars. In this case the correction to absolute parallax is probably greater than the amount usually applied to the McCormick relative parallaxes. A star of magnitude 9.5 having a proper-motion of a third of a second of arc per year has on the average a parallax of +0″.028 according to Table C of *Derivation of the Change of Colour with Distance and Apparent Magnitude* by P. J. VAN RHIJN, Groningen 1915. The measurement of twenty plates gives +0″.029 ± 0″.015 as the parallax of *B. D.* −22° 3557 relative to four comparison stars. The corresponding absolute parallax is +0″.034. Assuming that the other comparison stars used by OLIVIER have parallaxes of +0″.005, the correction to the relative parallax of γ *Hydrae* is +0″.015 giving an absolute parallax of +0″.022.

Leander McCormick Observatory,
February 21, 1921.

PARALLAX OF *NOVA AQUILAE* 3,

BY C. P. OLIVIER AND H. L. ALDEN.

Nova Aquilæ 3 was discovered independently by OLIVIER at $15^h 20^m$ G. M. T. on 1918 June 8 and the first plate for the determination of parallax was taken by ALDEN a couple of hours later. Additional plates were secured on June 9 and 19, but for all of them the parallax factors were small owing to the position of the *Nova* with respect to the *Sun* at the time of discovery.

Because of the interest attaching to this star and for the purpose of testing the errors of measurement in an extended series of plates, the plates were measured in duplicate. An approximate preliminary parallax of +0″.004 obtained from measures by OLIVIER of the plates of the first three epochs is given in the *Astronomical Journal* XXXII, 100. The final results contained in the present paper are based on twenty-nine plates taken in six epochs and extending over a period of more than two years. Five comparison stars were used by OLIVIER and four by ALDEN.

Due to the brightness of the *Nova* on 1918 June 8 and 9, the five plates taken on those dates were discarded from the solution. Means which have since

been devised for supplementing the rotating sector in cutting down the light of extremely bright stars were not available at that time and hence the images of the *Nova* on these plates were large and showed strongly the effect of diffraction due to the use of a very narrow opening of the rotating sector.

The final values of the relative parallax and the annual motion in right ascension are as follows: —

Observer	Relative Parallax	Probable error	Proper-motion
OLIVIER	$-0''.008$	$\pm 0''.007$	$-0''.018$
ALDEN	$-0\ .015$	$\pm 0\ .008$	$-0\ .008$
Mean	$-0\ .011$	$\pm 0\ .005$	$-0\ .014$

Assuming the average parallax of the comparison stars to be $+0''.005$, the absolute parallax of the *Nova* is $-0''.006$. The negative value thus obtained may be due to an appreciable parallax of one or more of the comparison stars. The distribution of residuals throughout the various epochs, however, is such as to suggest the presence of errors more or less accidental in character, and these are probably responsible for the negative parallax obtained. Full details of the measures will appear in the "Publications of the McCormick Observatory." It is sufficient to mention here that the plates are well up to the average quality of those taken at this Observatory and that twenty-six of the twenty-nine plates have residuals of the same sign for OLIVIER and ALDEN.

It should be pointed out that the size of the opening of the rotating sector varied from less than one degree to three hundred and sixty degrees for the various plates of the series, the plates of the last three epochs being taken without the sector. During the interval covered by the plates the brightness of the *Nova* fluctuated from magnitude minus one to magnitude nine. Also during the last four epochs the *Nova* showed a distinct disc whose diameter increased approximately with the time. Perhaps one or more of these conditions introduced errors which help to account for the negative parallax.

Other direct determinations of the parallax of *Nova Aquila* 3 are: —

Observer	Method	Relative parallax	Probable error	Reference
H. PHILIPPOT	Meridian circle	$+0''.197$	$\pm 0''.050$	1
H. PHILIPPOT	Meridian circle	$-0\ .04$	$\pm 1\ .14$	2
E. DELPORTE	Meridian circle	$+0\ .064$	$\pm 0\ .072$	3
L. COURVOISIER		$+0\ .071$	$\pm 0\ .013$	4
A. VAN MAANEN	Photography (preliminary)	$+0\ .060$	$\pm 0\ .004$	5
A. VAN MAANEN	Photography (final)	$+0\ .049$	$\pm 0\ .006$	6

All of these determinations except the final value of VAN MAANEN depend upon observations extending over a period of about a year.

Besides the direct determinations several values based on theoretical considerations have been published. C. LUPLAU-JANSSEN (7) has deduced parallaxes of $+0''.074$ and $+0''.059$ from the maximum apparent brightness and an assumed absolute magnitude of the *Nova* at maximum. TRUMPLER (8) derives a parallax of $+0''.006$ from the parallactic component of the proper-motion and $+0''.003$ from the tables of VAN RHIJN based on the magnitude and proper-motion of the *Nova* prior to the outburst.

The most reliable value of the directly measured parallax of *Nova Aquilæ* 3 is probably the mean of the final photographic values weighted in the usual manner. A correction of $+0''.002$ is applied to VAN MAANEN'S result to reduce to absolute parallax. The resulting value of the absolute parallax is $+0''.005 \pm 0''.004$, corresponding to a distance of 650 light-years.

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Leander McCormick Observatory,
April 1921.

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PHOTOGRAPHIC DETERMINATIONS OF THE PARALLAXES OF 70 STARS WITH THE THAW REFRACTOR.

By KEIVIN BURNS.

The mean number of plates used in these determinations is 16.4, and the mean number of comparison is 3.9. The mean probable error is ″.0074. One plate in 150 was rejected after measurement. In 19 regions an average of half the plates were measured by former members of the staff.

The column headed "A. O. α" gives the proper-motion of the parallax star in right ascension relative to the comparison stars. The preceeding column gives the absolute motion in right ascension as measured by Boss or PORTER. The last column gives the sector opening in per cent. an opening of 1.00 per cent indicates a reduction of about five magnitudes.

We are once more indebted to PROFESSOR BAILEY, to MISS CANNON, to PROFESSOR PORTER, and to PROFESSOR BOSS for data concerning magnitude, spectral class and proper-motion. The greater portion of the computing, including the least squares reductions, was done by MISS BERTHA GRIER.

The numbers are in continuation of earlier series. A detailed account of this work will appear in the *Publications of the Allegheny Observatory.*

Allegheny Observatory,
June 1, 1921,

No.	Name	α (1900)	δ (1900)	Durchmusterung No.	Vis. Mag.	Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax and P. E.		Sector o/o
		h m	° ′	°			″	″	″	″	″	
400	OΣ 18 (Br.)	0 37	+ 3 38	+ 3 93	7.6	F8	. . .	. . . . .	+.009	+.009	±.006	5.00
401	*μ Piscium* . . .	1 25	+ 5 38	+ 5 194	5.1	K	.297	+.293	+.278	+ 45	10	0.80
402	1 *Arietis*	1 45	+21 47	. . . .	. .	F5	17	− 11	− 15	+ 17	6	1.50
403	1 *Arietis*	1 45	+21 47	. . . .	.	A2	. .	. . . . .	− 9	+ 7	9	1.50
	Mean (Σ 174) .	. . . .	. . . . . .	+21 243	5.9	. .	. . .	. . . . .	. . . . .	+ 14	5	. . . .
404	*η Persei* (Br.) . .	2 43	+55 29	+55 714	3.9	K	33	+ 26	+ 26	+ 21	9	1.00
405	*κ Ceti*	3 14	+ 3 00	+ 2 518	5.0	K	283	+ 268	+ 268	+ 112	8	0.60
406	Σ 422	3 32	+ 0 16	. . . .	. . . . .	. . . . .	. . .	. . . .	− 38	+ 36	6	30.00
407	Σ 422	3 32	+ 0 16	. . . .	. . .	. . .	152	− 18	− 22	+ 43	16	30.00
	Mean	. . . .	. . . .	+ 0 616	6.1	G0	.	. . . . .	. . . .	+ 37	5	. . . .
408	*π^3 Orionis*	4 44	+ 6 47	+ 6 762	3.3	F8	474	+ 474	+ 450	+ 123	7	0.20
409	*i Tauri*	4 46	+18 46	+18 743	5.1	A5	94	+ 86	+ 73	+ 6	4	0.50
410	*ι Aurigae*	4 50	+33 00	+32 855	2.9	K2	30	+ 11	− 1	+ 16	7	0.30
411	*ϵ Aurigae*	4 55	+43 40	+43 1166	Var	F5p	15	+ 6	− 16	− 1	7	0.36
412	*P. M.* 572	5 23	+54 35	+54 902	7.6	G0	421	− 129	− 145	+ 22	7	15.00

No.	Name	α (1900)	δ (1900)	Durchmusterung No.	Vis Mag.	Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax	P. E.	Sector o/o
		h m	°	°			″	″	″	″	″	
413	ψ^7 *Aurigae*	6 44	+41 54	+41 1536	5.0	K	.136	−.017	−.022	−.008	±.007	1.40
414	ψ^8 *Aurigae*	6 46	+38 34	+38 1636	6.3	A	185	+ 31	+ 63	− 6	5	1.40
415	*Rumk* 2624	6 50	+40 13	+40 1758	8.4	K5	43-	+ 126	+ 126	+ 20	6	30.00
416	*B. D.* +40° 1759	6 51	+40 12	+40 1759	9.5	F5	...	...	− 17	− 13	6	30.00
417	*Lal.* 13784	7 02	+15 41	+15 1473	7.5	F8	231	− 60	− 78	+ 35	8	10.00
418	*Lal.* 13791	7 02	+15 41	+15 1476	7.4	F8	213	− 50	− 77	+ 25	8	10.00
	Mean	...	....	......	...		...	....	....	+ 30	6	...
419	20[1] *Lyncis* ...	7 15	+50 20	....	7.3	F0	64	− 28	− 9	− 3	4	6.00
420	20[2] *Lyncis*	7 15	+50 20	....	7.4	F0	47	− 9	− 11	+ 4	6	6.00
	Mean (Σ 1065)	....	.....	+50 1420	.....	.....	.	.....	...	− 1	3	
421	Σ 1093 (mean) .	7 23	+50 12	+50 1436	8.0	F5	..	...	+ 23	− 2	6	10.00
422	14 *Can. Min.* ..	7 53	+ 2 29	+ 2 1833	5.4	G2	184	− 156	− 153	+ 24	8	1.60
423	*Lal.* 15547	7 54	+21 08	+21 1731	8.6	G5	573	+ 178	+ 198	+ 38	8	7.00
424	*Fed.* 1217	7 56	+68 40	+68 518	7.6	F5	314	− 202	− 196	+ 15	6	12.00
425	*Groom.* 1437 ...	8 21	+45 59	+46 1398	6.3	F5	361	− 30	− 12	+ 40	6	1.00
426	*Lal.* 16616	8 25	+50 58	+51 1431	7.4	G0	376	− 96	− 75	+ 14	6	3.00
427	ι *Cancri*	8 41	+29 08	....	6.6	A5	..	.....	+ 29	+ 28	8	1.60
428	ι *Cancri*	8 41	+29 08	......	4.2	G5	52	− 18	+ 41	+ 7	6	1.00
	Mean (Σ 1268) .	..	......	+29 1824	.....	.....	.	.....	.....	+ 15	5	...
429	*Lal.* 17480	8 47	+ 8 27	+ 8 2134	6.6	G0	306	+ 178	+ 181	+ 14	7	1.50
430	*Lal.* 18397	9 16	+40 38	+40 2197	7.7	K2	521	− 347	− 340	+ 28	5	15.00
431	*h*23 *Urs. Maj.* .	9 24	+63 30	+63 845	3.8	F	117	+ 114	+ 120	+ 28	6	0.15
432	*Lal.* 20881	10 46	+20 49	+21 2247	8.1	F5	502	− 241	− 255	+ 21	9	10.00
433	*Groom.* 1930 ..	12 44	+60 52	+61 1320	5.9	F	96	+ 96	+ 126	+ 34	11	1.20
434	*Lal.* 25288	13 37	+ 8 54	+ 9 2798	6.1	G	387	− 378	− 368	+ 32	9	0.90
435	*Lal.* 26289	14 18	+ 1 43	+ 1 2920	6.3	G	525	+ 201	+ 160	+ 61	7	2.50
436	*A* 576 (mean)	14 28	+27 07	+27 2388	5.9	A	84	− 70	− 47	+ 6	8	1.00
437	*H* 2752 (Br.) ..	14 48	+45 01	+45 2228	8.0	F5		...	+ 41	− 34	10	12.00
438	*Lal.* 27742 ...	15 08	+19 39	....	..		668	− 599	− 569	+ 26	7	1.50
439	*Lal.* 27743 ..	15 08	+19 40	.....		...	654	− 591	− 572	+ 24	7	1.50
	Mean (Σ 1919)	.	.....	+19 2939	6.4	G		..	.	+ 25	5	....
440	μ^1 *Bootis*	15 21	+37 44	+37 2636	4.5	F	165	− 145	− 138	+ 13	8	0.25
441	δ *Serpentis* .	15 30	+10 53	......	5.2	..	58	− 58	− 56	+ 16	7	0.30
442	δ *Serpentis* ..	15 30	+10 53		4.2		66	− 65	− 67	+ 12	7	0.36
	Mean (Σ1954) .		..	+11 2821		A5	.	...	....	+ 14	5	....
443	χ *Herculis*	15 49	+42 44	+42 2648	4.6	F	763	+ 448	+ 455	+ 60	7	1.50
444	m^1 36 *Herculis* .	16 36	+ 4 24	+ 4 3234	6.9	....	21	− 12	+ 19	− 8	6	2.00
445	m^2 37 *Herculis* .	16 36	+ 4 25	+ 4 3235	5.7	...	14	− 3	+ 22	± 0	7	2.00
	Mean Σ31, Ap.I	...	...	... ...	.	A	.	.....	.....	− 5	5	....
446	ε *Herculis*	16 56	+31 04	+31 2947	3.9	A	48	− 42	− 62	+ 13	7	0.30

No.	Name	α (1900)	δ (1900)	Durchmusterung No.	Vis. Mag.	Class	Proper-Motion Catalog Total	Proper-Motion Catalog α	Proper-Motion A. O. α	Relative Parallax	and P. E.	Sector o/o
		h m	° ′	°			″	″	″	″	″	
447	*Lal.* 31174	17 04	+ 4 34	+ 4 3366	7.2	G0	.208	−.055	−.038	−.003	±.011	20.00
448	ψ^1 *Draconis*	17 44	+72 12	+72 804	4.9		267	+ 15	+ 27	+ 32	6	0.70
449	ψ^2 *Draconis*	17 44	+72 12	+72 805	6.1		279	+ 21	+ 26	+ 56	8	0.70
	Mean (Σ 2241)	. . .		. . . .	. .	F5			.	+ 37	5	. . . .
450	ζ^1 *Lyrae*	18 41	+37 30	+37 3222	4.3	F	34	+ 30	+ 49	+ 21	7	0.40
451	ζ^2 *Lyrae*	18 41	+37 29	+37 3223	5.9	A5	25	+ 23	+ 28	+ 25	8	0.40
	Mean	.	. . . . .	. . . .	. . . . . .	. . .		. .	. . . .	+ 23	5	. . .
452	W_2 18ʰ 979	18 34	+28 51	+28 3039	8	.	17 −	− 39	− 48	+ 47	5	15.00
453	*Lal.* 35248	18 51	− 5 52	− 5 4811	8.2	G5	415	− 191	− 200	+ 32	11	13.00
454	3 *Cygni*	19 21	+24 44	+24 3737	6.2	K	658	− 184	− 163	+ 25	10	1.80
455	χ *Aquilae* (M)	19 38	+11 35	+11 3955	5.3	F2	15	+ 4	+ 5	− 1	4	1.50
456	γ *Aquilae*	19 42	+10 22	+10 4043	2.8	K2	18	+ 17	− 3	± 0	7	0.80
457	δ *Sagittae*	19 43	+18 17	+18 4240	3.8	Map	9	+ 5	+ 8	− 12	7	0.70
458	ε *Draconis* (Br)	19 48	+70 01	+69 1070	4.0	K	89	+ 84	+ 87	− 3	10	0.40
459	24 *Vulpeculae*	20 12	+24 22	+24 4075	5.4	K	30	+ 22	− 4	− 31	7	3.00
460	*Groom.* 3196	20 27	+45 35	+45 3196	6.6	K	173	+ 74	+ 75	+ 4	7	3.50
461	*Lal.* 39956	20 36	+19 34	+19 4484	6.4	F8	337	+ 130	+ 136	+ 50	7	3.00
462	δ *Equulei* (Mean)	21 10	+ 9 36	+ 9 4746	4.6	F5	308	+ 45	+ 29	+ 67	7	0.30
463	α *Cephei*	21 16	+62 10	+61 2111	2.6	A5	163	+ 156	+ 120	+ 66	7	0.20
464	*B. D.* +32° 4134	21 17	+32 11	+32 4134	6.0	A	. .	+ 32	+ 29	+ 2	8	2.00
465	OΣ 455 (Br.)	21 52	+15 38	+15 4528	8.3	F8		. . . . .	− 18	+ 18	9	25.00
466	ζ^1 *Aquarii*	22 24	− 0 32	. . . .	4.6	. .	176	+ 175	+ 174	− 3	10	0.40
467	ζ^2 *Aquarii*	22 24	− 0 32	. . . . .	4.4	. .	214	+ 210	+ 175	− 8	10	0.40
	Mean (Σ 2909)	.	. . .	− 0 4365	. .	F5	. .	. . . .	. . . .	− 6	7	. . .
468	55 *Pegasi*	23 02	+ 8 52	+ 8 4997	4.7	M	19	+ 10	+ 3	− 6	7	2.00
469	γ *Cephei*	23 35	+77 04	+76 928	3.4	K	167	− 59	− 52	+ 63	8	0.20

VARIATION OF LATITUDE OBSERVATIONS AT THE U. S. NAVAL OBSERVATORY,

By F. B. LITTELL.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

The observers during the period 1920.0–1921.0 were F. B. LITTELL, G. A. HILL and J. D. WISE. Most of the plates were measured by MR. WISE, the others were measured by the writer. The program and star list were the same as used in the period 1915.9–1920.0, the results of which are contained in *A. J.* No. 783.

The scale value was corrected by the results of the observations during the year. The probable error of a latitude from a single star was ±0″.098 which is a little larger than those of the four preceding years during which it ranged from ±0″.086 to ±0″.093.

The value of the constant of aberration deduced from the closing error for this year is 20″.449. The separate values for each of the five years covered by this work are given below for comparison. The probable errors of the separate yearly determinations as deduced from the residuals of the group differences range from ±0″.013 to ±0″.015.

1916	20.440	
1917	20.476	
1918	20.467	
1919	20.413	
1920	20.449	
Mean	20.449	$\pm 0''.007$

Table 1 gives the difference between the variation of latitude observed with the photographic zenith tube and that computed for Washington from the data published by Prof. B. Wanach in *A. N.* 5075. Prof. Wanach has omitted the z term in deducing the elements of the polar motion but from the symmetrical situation of the three stations upon whose work the results are based it can be assumed that the values of x and y are not materially different from what they would have been if the z term had been included. A constant quantity has been applied to make the differences symmetrical with zero.

There is strong indications of the z term in these differences for each year, although it is somewhat less marked in 1919. From the mean values in the last column the following formula has been deduced in which t stands for the tenth of the year.

$$z = -0''.010 + 0''.064 \sin (360^\circ t + 132^\circ.6)$$

Table 1. Variation of Latitude at Washington. P. Z. T. Minus International

z Term Not Used

	1915	1916	1917	1918	1919	1920	Mean
	″	″	″	″	″	″	″
.0	....	+0.07	+0.04	+0.06	−0.01	+0.03	+0.038
.1	....	+ .06	− .01	+ .03	− .03	.....	+ .012
.2	....	− .02	− .06	− .09	− .03	.....	− .050
.3	....	− .07	− .06	− .12	+ .01	.....	− .060
.4	....	− .05	− .10	− .13	.00	.....	− .070
.5	....	− .01	− .06	− .11	− .06	.....	− .060
.6	....	+ .01	− .01	− .06	− .01	.....	− .018
.7	....	+ .03	0	+ .01	+ .02	.....	+ .015
.8	....	+ .03	+ .02	+ .07	+ .05	.....	+ .042
.9	+.03	+ .06	+ .06	+ .06	+ .07	.....	+ .056

Variation of Latitude at Washington. P. Z. T. Minus International

Corrected for z Term

	1915	1916	1917	1918	1919	1920	Mean
	″	″	″	″	″	″	″
.0	....	+0.03	0.00	+0.02	−0.05	−0.01	−0.002
.1	....	+ .06	− .01	+ .03	− .03	.....	+ .012
.2	...	+ .02	− .02	− .05	+ .01	...	− .010
.3		.00	+ .01	− .05	+ .08	....	+ .010
.4	.	+ .02	− .03	− .06	+ .07	..	.000
.5		+ .05	.00	− .05	.00		.000
.6	.	+ .03	+ .01	− .04	+ .01		+ .002
.7		+ .01	− .02	− .01	.00		− .005
.8	.	− .02	− .03	+ .02	.00		− .008
.9	−.02	+ .01	+ .01	+ .01	+ .02		+ 006

This is very similar to the result obtained from the results of 12 years work at all the stations of the International Geodetic Association, see *Resultate des Internationalen Breitendienstes*, Band V, p. 188.

The second part of the table gives the differences corrected by the application of the z term found above.

Table 2 gives the variation of latitude at Washington for each twentieth of a year as deduced from the latitude curve.

Table 2

Corrections to Mean Latitude for Washington

	′		″
1919.95	+0.04	1920.50	+0.01
1920.00	+ .07	.55	− .03
.05	+ .10	.60	− .07
.10	+ .12	.65	− .09
.15	+ .13	.70	− .11
.20	+ .14	.75	− .12
.25	+ .13	.80	− .13
.30	+ .12	.85	− .14
.35	+ .09	.90	− .13
.40	+ .06	1920.95	[− .10]
1920.45	+ .04	1921.06	[− .06]

Table 3 gives for each observing night, the initial of the observer, the number of stars observed and the resulting observed excess of the latitude of the instrument over +38° 55′ 16″.00 for each group, the mean for the night, and the correction to reduce the observed latitude to that given by the adopted curve.

Table 3

Observed Latitudes of the Photographic Zenith Tube

Date	Obsr.	No. Obs.		Ob'd Latitude			v
1920		ii	iii	ii	iii	Mean	
				″		″	″
Jan. 1.4	L	8	..	1.12	...	1.12	−0.02
5.4	L	8	8	1.07	1.11	1.09	+ .02
		iii	iv	iii	iv	Mean	
Jan. 12.5	L	8	8	1.05	1.04	1.04	+ .08
13.5	H	8	6	0.98	1.25	1.09	+ .03
19.5	L	5	6	1.34	1.19	1.26	− .13
		iii	iv	iii	iv	Mean	
				″		″	″
Jan. 28.5	L	8	8	1.10	1.13	1.11	+0.03
29.5	H	..	5		1.09	1.09	+ .05
30.5	L	8	4	1.16	1.16	1.16	− .02
31.5	H	..	2	..	1.07	1.07	+ .07
Feb. 10.5	H	7	7	1.28	0.98	1.13	+ .02
11.4	L	5	.	1.30	...	1.30	− .15
13.4	L	8	8	1.13	1.15	1.14	+ .01
17.4	L	8	7	1.20	1.23	1.21	− .06
19.4	H	8	7	1.19	1.16	1.17	− .01
20.4	L	2	..	1.08	..	1.08	+ .08
27.4	L	6	8	1.21	1.03	1.11	+ .05
Mar. 1.4	H	7	6	1.33	1.10	1.22	− .06
2.4	L	8	8	1.12	1.13	1.12	+ .04
		iv	v	iv	v	Mean	
Mar. 3.5	W	6	3	1.16	1.03	1.12	+ .04
6.5	W	8	4	1.24	1.37	1.28	− .12
8.5	H	6	7	1.15	1.23	1.20	− .04
9.5	L	6	8	1.16	1.25	1.21	− .05
17.5	W	3	5	1.05	1.12	1.10	+ .07
21.5	L	8	8	1.18	1.22	1.20	− .03
22.5	H	8	6	1.07	1.06	1.07	+ .10
23.5	W	7	6	1.12	1.10	1.11	+ .06
27.5	W	6	8	1.11	1.13	1.12	+ .05
30.5	L	..	7	...	1.19	1.19	− .02
Apr. 2.5	L	7	6	1.11	1.34	1.22	− .06
7.5	W	2	8	1.36	1.08	1.14	+ .02
8.4	H	1	2	1.31	1.02	1.12	+ .04
9.4	L	7	5	1.28	1.06	1.19	− .03
10.4	W	7	8	1.20	1.17	1.18	− .02
14.4	W	7	8	1.04	1.20	1.13	+ .02
		v	vi	v	vi	Mean	
Apr. 21.6	W	8	8	1.25	1.25	1.25	− .11
22.5	H	6	..	1.21	...	1.21	− .07
24.6	W	7	8	1.17	1.17	1.17	− .03
28.5	W	7	8	1.11	1.05	1.08	+ .05
29.5	H	5	..	1.02	.	1.02	+ .11
May 1.5	W	8	8	1.20	1.15	1.18	− .05
3.4	H	8	..	1.06	...	1.06	+ .06
4.5	L	7	8	1.08	1.18	1.14	− .02
5.5	W	7	8	1.09	1.04	1.07	+ .05
6.4	L	6	..	1.02	...	1.02	+ .10
8.5	W	4	7	1.03	1.22	1.15	− .03
14.4	L	7	..	1.16	...	1.16	− .05
15.5	W	8	8	1.16	1.04	1.10	.00
22.5	W	7	7	1.23	1.10	1.17	− .08
25.4	L	4	..	1.00	...	1.00	+ .09
26.5	W	6	7	1.04	1.07	1.05	+ .04

Date	Obsr.	No. Obs.		Ob'd Latitude			ν
1920		v	vi	v	vi	Mean	
				″		″	″
May 27.5	H	7	8	1.09	1.01	1.05	+0.04
28.5	L	5	5	1.14	1.10	1.12	− .03
29.5	W	5	7	1.29	1.10	1.18	− .09
June 1.5	L	5	8	1.08	0.94	1.00	+ .08
		vi	vii	vi	vii	Mean	
June 6.6	W	8	8	1.12	1.03	1.08	.00
9.6	W	7	7	1.07	0.99	1.03	+ .04
11.5	L	6	7	1.16	1.12	1.13	− .06
13.5	W	7	6	1.11	1.10	1.11	− .04
18.5	L	6	7	1.07	1.02	1.04	+ .02
22.5	L	5	2	1.09	1.14	1.10	− .05
23.5	W	7	8	1.05	0.94	0.99	+ .06
25.5	L	7	7	1.14	1.01	1.08	− .03
26.5	W	7	7	1.08	0.98	1.03	+ .02
28.5	H	7	5	1.00	1.06	1.03	+ .02
July 3.5	W	8	8	1.08	1.00	1.04	.00
7.4	W	3	.	1.12		1.12	− .09
8.5	L	6	8	1.08	1.04	1.05	− .02
10.4	W	8	2	1.23	1.10	1.21	− .19
12.4	H	6	3	1.05	0.84	0.98	+ .04
13.5	L	6	7	1.05	0.91	0.98	+ .03
		vii	viii	vii	viii	Mean	
July 21.6	W	2	7	0.97	0.94	0.95	+ .04
23.6	L	..	6	...	1.06	1.06	− .07
25.5	W	8	8	1.08	0.89	0.99	.00
27.5	L	7	8	0.91	0.92	0.92	+ .06
28.5	W	8	8	0.89	1.01	0.95	+ .03
29.5	H	8	8	0.89	0.90	0.90	+ .08
Aug. 2.5	L	8	8	0.91	0.95	0.93	+ .04
3.5	W	8	8	0.97	0.99	0.98	− .01
8.5	W	8	7	0.94	0.92	0.93	+ .03
21.4	H	7	7	1.00	0.89	0.94	.00
30.4	H	5		1.04		1.04	− .11
Sept. 2.4	W	8	7	0.90	1.02	*	...
4.4	W	8	8	0.84	0.97	*	..
		viii	i	viii	i	Mean	
Sept. 1.5	H	8	8	0.94	1.03	0.99	− .06
2.5	W	7	8	1.02	1.00	0.97*	− .04
4.5	W	8	8	0.97	1.01	0.94*	− .01
6.4	L	5	.	0.93	.	0.93	.00
7.6	W		8	...	0.87	0.87	+ .05
10.5	W	5	4	0.92	0.97	0.94	− .02
12.5	L	7	4	0.90	0.98	0.93	− .01
13.5	W	7	8	0.84	0.90	0.87	+ .05
14.5	W	8	8	0.96	0.99	0.97	− .05

* Three groups observed. Mean of all under the group pair VIII, I.

Date	Obsr.	No. Obs.		Ob'd Latitude			ν
1920		viii	i	viii	i	Mean	
				″		″	″
Sept. 15.5	L	8	8	0.89	0.80	0.84	+0.08
16.5	W	8	8	1.05	1.15	1.10	− .19
18.5	W	7	6	0.84	0.83	0.83	+ .08
20.4	W	5	.	0.93	..	0.93	− .02
21.5	L	8	8	0.81	0.79	0.80	+ .11
22.4	W	7	5	0.95	1.03	0.98	− .07
25.4	W	2	.	0.87	...	0.87	+ .04
27.4	L	3	.	0.87	.	0.87	+ .04
28.4	W	5		1.06	.	1.06	− .15
Oct. 1.4	L	8	8	0.89	0.80	0.84	+ .06
		i	ii	i	ii	Mean	
Oct. 2.5	W	8	8	0.87	0.90	0.88	+ .02
5.5	W	8	8	0.86	0.89	0.87	+ .03
8.6	L	1	3	0.90	0.91	0.91	− .01
9.5	W	5	8	0.85	1.01	0.95	− .05
11.5	L	8	8	0.83	0.80	0.82	+ .08
12.5	W	7	5	0.95	1.01	0.97	− .07
14.5	W	8	7	0.94	0.96	0.95	− .05
19.5	W	7	8	0.95	0.88	0.91	− .02
21.5	W	6	2	0.90	1.06	0.94	− .05
23.5	W	8	8	0.85	0.91	0.88	+ .01
29.4	W	7	..	0.76	..	0.76	+ .13
30.5	W	8	8	0.90	0.85	0.88	+ .01
Nov. 3.5	L	8	8	0.87	0.91	0.89	.00
4.5	W	8	8	0.77	0.83	0.80	+ .09
12.4	W	8	8	0.77	1.01	0.89	.00
13.4	W	8	8	0.83	0.97	0.90	− .01
18.4	W	8	7	0.86	0.82	0.84	+ .05
		ii	iii	ii	iii	Mean	
Nov. 20.5	W	8	8	0.96	0.96	0.96	− .06
Dec. 1.4	L	3	.	1.07	.	1.07	− .16
2.4	W	8	.	0.88		0.88	+ .03
6.5	L	8	3	0.92	0.89	0.91	+ .01
11.5	L	8	6	0.85	0.88	6.86	+ .07
14.5	W	8	8	0.97	0.97	0.97	− .04
17.4	L	2	.	0.90	...	0.90	+ .04
18.5	W	8	8	0.93	0.91	0.92	+ .03
20.5	L	8	8	0.87	0.89	0.88	+ .07
23.4	W	7		1.03	.	1.03	− .07
28.4	W	8	8	0.97	0.99	0.98	− .01
1921							
Jan. 1.4	W	8	2	0.94	0.88	0.93	
2.4	W	8	1	1.13	0.98	1.11	
3.4	L	8	8	0.98	0.94	0.96	
4.4	W	6	2	0.97	0.81	0.93	
6.4	W	8	8	0.98	1.02	1.06	
10.5	L		8	..	1.01	1.01	
12.4	L	7	8	1.08	0.91	0.99	.

OBSERVATIONS OF COMET 1920 *b* (*TAYLOR*),

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

By ERNEST CLARE BOWER.

[Communicated by Rear Admiral J. A. Hoogewerff, U. S. Navy, Superintendent.]

G. M. T	App. α	App δ	☄ — ★		Comp.	Log $p\rho$		Ap. pl. red. of ★		Seeing	★
	h m s	° ′ ″	m s	′ ″				s	″		
1920 Dec. 20.82098	9 31 22.69	+ 1 7 59.7	−1 52.43	+2 30.8	*t*35 , 7	9.066*n*	0.730	+4.37	−23.7	*g*	1
1921 Jan. 18.82969	11 4 32.22	+35 3 9.6	+0 16.33	−5 12.8	*d*10 , 8	8.792*n*	9.768	+1.53	−18.9	*g*	2
Feb. 14.72619	11 14 44.63	+45 57 7.2	−0 2.55	−1 29.6	*d*10 , 8	9.344*n*	9.910*n*	+2.24	−18.4	*g*	3

Dec. 20. 10ᵐ. Jan. 18. 11½ᵐ. Feb. 14. 13½ᵐ. Faint.

Mean Places of Comparison Stars for Beginning of Year

★	α	δ	Authority
	h m s	° ′ ″	
1	9 33 10.75	+ 1 5 52.6	*A. G. Albany* 3826
2	11 4 14.36	+35 8 41.3	*A. G. Lund* 5132
3	11 14 44.94	+45 58 55.2	*A. G. Bonn* 7982

U. S. Naval Observatory, Washington, D. C.,
1921, April 2.

CORRECTION TO THE *AMERICAN EPHERMERIS* AND *NAUTICAL ALMANAC*.

The proper-motion in right ascension of the star *ω Herculis*, 16ʰ 21ᵐ 35ˢ, should evidently be plus, instead of minus.

The error dates back to the *Fundamental Catalogue of Newcomb*, in which the right ascension for 1875 is correct, but that for 1900 includes the effect of the error, and the sign of the proper-motion is wrong for both epochs.

The correction to the ephemeris right ascension, at the present time, is +0ˢ.25.

R. H. Tucker

Lick Observatory,
June 1, 1921.

NOTE UPON A COMPARISON OF PROPER-MOTIONS,

By GEORGE C. COMSTOCK.

In connection with an investigation of the motions of faint stars I have had occasion to determine the proper-motions of some hundreds of brighter stars used as reference points. These motions have been determined with reference to the Boss system, using the systematic corrections and weights set forth in the *Preliminary General Catalogue* plus an extension of these data to certain recent series of observations not considered in the *P. G. C.* These results will be incorporated in a forthcoming volume of *Publications of the Washburn Observatory* but prior to such publication I have sought to control the proper-motions thus found by comparison with results elsewhere obtained and have utilized for that purpose *inter alia* the recently

received Greenwich Catalogue of Stars for 1910.0, Part II. Stars in the Zone $+24°.0$ to $+32°.0$.

These Greenwich proper-motions are very closely related to the Boss system and possess special interest for the present purpose since they are derived from data almost wholly different from that which I have utilized, *viz.*, the only catalogue places common to these Greenwich determinations of proper-motions and my own are the A. G. Zones, which although incorporated in my discussions have little influence upon the proper-motions since their dates of observation fall near the mean epoch of all my data. Their influence upon the Greenwich proper-motions is more considerable, but these seem to depend mainly upon Lalande and Bessel's Zones, corrected and reduced to the Boss system by means of the *P. G. C.*

Although there are only 18 stars common to the Greenwich results and my own, I have compared their proper-motions as follows:

Difference of Centennial Proper-Motions

COMSTOCK — GREENWICH

Gh. No.	$\Delta\mu_\alpha$	$\Delta\mu_\delta$	Mag.
370	+0.34	+0.5	7.6
688	− .05	+ .1	7.9
1705	+ .34	− .6	7.9
1775	+ .06	− .7	7.5
2902	− .03	− .5	7.2
4729	− .36	+ .4	6.4
5344	+ .16	− .1	7.4
5889	+ .11	+2.2	6.7
6203	− .06	+ .6	6.4
6632	+ .13	−5.2	8.9
6654	+ .08	+ .1	7.9
6853	− .01	−2.4	7.7
7022	+ .01	+2.0	7.9
7427	+ .14	− .1	7.4
8285	− .02	+1.0	8.2
8683	− .13	− .8	8.6
8883	+ .03	− .1	6.3
11434	+ .04	+2.1	7.9

The maximum discordance above shown is in each coördinate of the order 5″ per century which if charged to the observations of Lalande and Bessel seems not unduly large. That these disparities should be charged to the early observations named rather than to Greenwich or my own data is evident from the fact that the Greenwich places for 1910 agree well with my elements of the stars' motion. I therefore adopt as a mean relation between the proper-motions considered the simple mean of the foregoing numbers:

$$C - Gh.\ \Delta\mu_\alpha = +0^s.04 \pm 0^s.025 \quad \Delta\mu_\delta = -0''.1 \pm 0''.27$$

My own proper-motions having been derived from least square solutions a probable error is available for each of the 36 values of μ under consideration and I find that, expressed in arc of a great circle, these probable errors range from $\pm 0''.40$ to $\pm 0''.95$ and their means are, in R. A. $\pm 0^s.055$, in Dec. $\pm 0''.62$.

The corresponding probable errors of the Greenwich results are estimated at p. B xix of the volume cited, to be $\pm 0^s.10$ and $\pm 1''.0$ respectively. Combining the foregoing numbers I find for the probable error to be anticipated for a single difference of proper-motion the numbers shown in the first line of the following exhibit:

P. E. of a Single $\Delta\mu$ $C - Gh$

Derived from,	In R. A.	In Dec.
A' priori estimates	$\pm 0^s.11$	$\pm 1''.2$
Actual residuals	± 0.108	± 1.15

The close agreement between these probable errors obtained *á priori* and *á posteriori* tends to confirm the estimated measure of precision for each series of results and to strengthen the conclusion that the mean systematic difference found between them is a quantity of the same order of magnitude as the probable uncertainty of its determination.

Washburn Observatory,
May, 1921.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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OCCULTATIONS BY THE *MOON*,

OBSERVED WITH THE 26-INCH AND 12-INCH EQUATORIALS OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral J. A. HOOGEWERFF, U. S. Navy, Superintendent.]

Date	Object	Phen.	26-Inch W. Sid. T.	W. M. T.	Sec'g	Pow'r	Obs	Rem	12-Inch W. Sid. T.	W. M. T.	Sec'g	Pow'r	Obs.	Rem
1920			h m s	h m s					h m s	h m s				
July 2	*β Capricorni*	DB						..	22 48 16.1	16 3 54.0	*p*	160	B	1
25	123 *B. Scorpii*	DD	19 59 44.5	11 45 24.1	*p*	183	HL							
28	187 *B. Sagittarii*	DD	16 19 49.1	7 54 17.0	*f*	178	HL	2	16 19 49.0	7 54 16.9	*p*	160	B	4
28	187 *B. Sagittarii*	RB	17 40 40.5	9 14 55.1	*f*	183	HL	3	17 40 13.8	9 14 58.4	*f*	160	B	5
Aug. 30	25 *Piscium*	DB	0 20 37.7	13 44 1.8	*f*	183	HL	6						
30	25 *Piscium*	RD	1 16 34.3	14 39 49.3	*f*	183	HL	7	1 16 16.2	14 40 1.1	*vp*	160	B	8
Sept. 21	*ρ Sagittarii*	DD	18 37 34.2	6 35 24.5	*g*	183	B	4						
21	*ρ Sagittarii*	RB	20 7 41.2	8 5 16.8	*f*	178	B	9						
Oct. 3	19 *B. Geminorum*	DB	3 28 26.4	14 37 39.0	*g*	183	HL	..						
3	19 *B. Geminorum*	RD	4 43 49.2	15 52 49.4	*f*	183	HL	10						
6	*κ Cancri*	DB	3 45 8.3	14 42 30.4	*p*	183	HL	11	3 45 9.1	14 42 31.2	*vp*	160	B	13
6	*κ Cancri*	RD	4 46 31.5	15 43 43.5	*f*	183	HL	12	4 46 31.5	15 43 43.5	*f*	115	B	4
17	39 *G. Sagittarii*	RB	20 16 1.8	6 31 22.5	*f*	183	HL	23						
25	60 *Piscium*	DD	21 6 45.8	6 50 30.9	*f*	183	HL	14						
25	60 *Piscium*	RB	22 17 9.4	8 0 43.0	*f*	183	HL	15						
29	302 *B. Tauri*	DB	0 57 3.2	10 24 27.0	*p*	183	HL	16						
29	302 *B. Tauri*	RD	2 0 0.7	11 27 14.1	*p*	183	HL	..						
29	*i Tauri*	DB	3 42 56.9	13 9 53.5	*p*	183	HL	..						
29	*i Tauri*	RD	4 46 6.4	14 12 52.6	*f*	183	HL	..						
Nov. 25	85 *H' Tauri*	DB	3 24 22.3	11 5 12.4	*f*	183	HL	.						
25	85 *H' Tauri*	RD	4 19 10.3	11 59 51.4	*f*	183	HL	17						
Dec. 15	*c' Capricorni*	DD	1 27 37.1	7 50 8.1	*p*	183	HL	10	1 27 37.2	7 50 8.2	*f*	...	B	4
23	302 *B. Tauri*	DD	1 35 56.8	7 26 59.1	*p*	183	HL	18						
23	302 *B. Tauri*	RB	2 37 35.5	8 28 27.7	*vp*	183	HL	19						
23	*i Tauri*	DD	4 23 0.6	10 13 35.6	*f*	183	HL	..						
1921														
Jan. 23	84 *B. Cancri*	DB	5 7 51.6	8 56 26.0	*p*	183	HL	20						
23	84 *B. Cancri*	RD	6 18 31.2	10 6 54.0	*f*	183	HL	35						

Date	Object	Phen.	26-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem	12-Inch W. Sid. T.	W. M. T.	See'g	Pow'r	Obs.	Rem
1921			h m s	h m s					h m s	h m s				
Jan. 23	A^1 *Cancri*	DB	10 31 26.2	14 19 7.5	*g*	183	HL	..	....	....	.	...	.	..
23	A^1 *Cancri*	RD	11 13 7.3	15 0 41.8	*f*	183	HL	35	....	....	.	...	.	..
23	A^2 *Cancri*	DB	12 24 47.0	16 12 9.8	*f*	183	HL	..	....	....	.	...	.	..
23	A^2 *Cancri*	RD	13 23 7.9	17 10 21.1	*f*	183	HL	35	....	....	.	...	.	..
Feb. 15	162 *B. Tauri*	DD	7 21 47.0	9 39 33.5	*f*	183	HL	10	....	....	.	...	.	..
15	162 *B. Tauri*	RB	7 51 3.0	10 8 44.8	*f*	183	HL	21	....	....	.	...	.	..
16	*m Tauri*	DD	10 47 50.0	13 1 6.8	*p*	183	B	4	....	....	.	...	.	..
20	*κ Cancri*	DD	9 0 28.5	10 58 19.3	*f*	183	HL	22	....	....	.	...	.	..
20	*κ Cancri*	RB	9 43 53.1	11 41 36.8	*f*	183	HL	..	....	....	.	...	.	..
Apr. 11	68 *Tauri*	DD	8 26 52.4	7 8 13.4	*f*	183	HL	10	8 26 52.5	7 8 13.5	*f*	115	B	4
11	68 *Tauri*	RB	9 27 17.0	8 8 28.1	*f*	183	HL	23	9 27 16.1	8 8 27.2	*p*	160	B	24
21	*B.D.* −12.3931	RE	16 30 2.8	14 30 45.6	*f*	183	HL	25	16 30 15.2	14 30 57.9	*f*	115	B	30
21	*B.D.* −11.3647	RE	16 39 48.0	14 40 29.2	*f*	183	HL	26	16 39 46.3	14 40 27.5	*f*	115	B	31
21	*B.D.* −12.3932	DE	15 37 42.7	13 38 34.0	*f*	183	HL	27	15 37 42.8	13 38 34.2	*f*	115	B	4
21	*B.D.* −12.3932	RE	16 56 1.5	14 56 40.0	*f*	183	HL	28	16 56 1.7	14 56 40.2	*f*	115	B	32
21	*B.D.* −12.3941	DE	16 27 57.6	14 28 40.7	*f*	183	HL	27	16 27 58.2	14 28 41.4	*f*	115	B	33
21	*B.D.* −12.3940	DE	16 36 41.1	14 37 22.8	*f*	183	HL	29	16 36 41.2	14 37 22.9	*f*	115	B	4
21	*B.D.* −12.3942	DE	16 41 12.3	14 41 53.2	*f*	183	HL	29	16 41 11.9	14 41 52.8	*f*	115	B	34

The occultations visible at Washington during the lunar eclipse of April 21 were predicted by the *Nautical Almanac* Office.

Occulting bars were attached to powers 178 and 160.

Phen.: DD = disappearance dark limb; DB = disappearance bright limb; DE = disappearance eclipsed limb; RD = reappearance dark limb; RB = reappearance bright limb; RE = reappearance eclipsed limb.

Obs.: HL = A. Hall; B = Ernest Clare Bower.

Rem.: (1) $\pm 1\frac{1}{2}^s$. (2) Late $0^s.5$. Gradual. (3) Late 1^s. (4) Late $0^s.1$. (5) Late $3^s \pm 2^s$. (6) Very uncertain. Very faint. Clouds. (7) Uncertain whether real reappearance. Clouds. (8) Late, probably not over 5^s. Clouds. (9) Late $1^s.5 \pm 1^s$. (10) Dark limb visible. (11) Uncertain several seconds. (12) Late $0^s.2$. Dark limb visible. (13) $\pm 2^s$. (14) Late $0^s.2$. Clouds. (15) Late $0^s.5$. Clouds. (16) Uncertain 1^s or 2^s. (17) Late. Eyepiece fogged. (18) Late $0^s.2$. (19) Late. Eyepiece fogged. (20) Early. (21) Late, perhaps 2^s. Star very faint. Clouds. (22) A little early. (23) Late $0^s.5$ (24) Late $4^s \pm 2^s$. (25) Late 1^s. Haze. (26) Late 1^s. Eye and ear. Haze. (27) Haze. Clouds. (28) Late $0^s.5$. Haze. Clouds. (29) Eye and ear. Haze. Clouds. (30) Late $10^s \pm$. (31) Late $1^s.5 \pm$. (32) Late $0^s.3$. (33) Late $0^s.2 \pm 0^s.3$. Star very faint near limb. (34) Late $0^s.15$. (35) Late.

U. S. Naval Observatory, Washington, D. C.
1921, April 28.

DEPENDENCE OF ORBITAL ECCENTRICITY UPON THE RELATIVE MASSES OF THE COMPONENTS,

By C. D. PERRINE.

Among the spectroscopic binaries the systems with the smaller secondaries have been observed to have, in general, the larger orbital eccentricities. Further examination discloses a similar condition among the

visual binaries and among the bodies of the solar system. The object of the present preliminary paper is to draw attention to this dependence.

Spectroscopic Binaries

The spectroscopic binaries, in which the spectrum of only one component is visible, furnish the relative masses affected by the uncertainties of orbital inclination. Groups should, however, reduce such uncertainties. The classification has been limited to periods of 30 days and less, owing chiefly to the scarcity of stars with periods longer and in order to eliminate as far as possible any dependence of eccentricity upon length of period. Three stars (4% of the whole) with relatively long periods and large eccentricities have been omitted because of their undue influence in such small groups and because they belong to spectral classes *B* and *Ap*.

The amount of data is limited and the individual values in some of the groups show a wide range. Examination of these groups in detail shows enough consistency with respect to the distributions of large and small values to confirm the progression shown in the means for the *A* to *M* stars.

The results are given in Table I.

Table I

Spectroscopic Binaries

Dependence upon Mass — Ratio

Spectral Class	*B*				*A* to *M*			
$\frac{m^3_1 \sin^3 i}{(m+m_1)^2}$	No. Stars	e	P	$\frac{m^3_1 \sin^3 i}{(m+m_1)^2}$	No. Stars	e	P	$\frac{m^3_1 \sin^3 i}{(m+m_1)^2}$
Cepheids 0 to 0.0066	..	...	d ..	....	21	0.26	d 6.0	0.0024
0 to 0.0099	10	0.12	6.1	0.002	9	0.23	8.1	0.0033
0.010 to 0.099	4	0.04	5.0	0.050	13	0.18	8.2	0.042
0.100 to 0.499	8	0.06	5.1	0.217	5	0.05	8.0	0.182
0.500 and over	7	0.09	6.3	2.348	..	...	..	.....

The *B* stars as a class in this table do not show the dependence with certainty. The small and irregular effect may or may not be real. The effect shown in the later types is worthy of greater confidence.

Twenty-six stars yield, thru observations of the spectra of both components, their relative masses free from uncertainties of orbital inclination. There is too little difference in the masses of the components of such stars of later type to justify investigation. Fourteen stars of class *B* show a small dependence of eccentricity upon relative mass.

Visual Binaries

If we may assume that, in general, differences of mass will correspond to differences of brightness, it is possible to obtain evidence from the visual binaries. The results for 57 systems with well determined periods (shorter than 200 years) are given in Table II.

Table II

Visual Binaries, Eccentricity and Δ Magnitude

e	Mean e	Δ Mag.	No. of Stars
0.00 to 0.29	0.19	0.60	7
0.30 to 0.44	0.37	1.29	16
*0.30 to 0.44	0.37	0.95	15
0.45 to 0.58	0.50	1.32	18
0.59 and over	0.71	2.04	16
†0.59 and over	0.71	1.47	15

*Omitting 85 *Pegasi*

†Omitting *Sirius*.

Although there is considerable range among the individual values and several small differences of brightness among the larger eccentricities, there is

enough consistency among the larger values of Δ magnitude to give confidence in the observed progression.

The Solar System

Traces of a dependence of eccentricity upon relative mass are found among the major planets, the satellites and the minor planets of the solar system. The results for these are given in Tables III, IV and V.

Table III

Major Planets*

Planet	Eccentricity	Mass ⊕ = 1
Mercury	0.206	0.05
Venus	.007	0.82
Earth	.017	1.00
Mars	.092	0.11
Jupiter	.048	317.7
Saturn	.056	94.8
Uranus	.046	14.6
Neptune	.009	17.0

*Taken from Young's *General Astronomy*, Table I.

The eight major planets show this dependence in a general way. The four inner planets by themselves are quite consistent. *Mercury*, the smallest of all, has the highest eccentricity. *Mars* next in size has the next largest. *Venus* and the *Earth* are considerably larger, nearly equal in size and their orbits are nearly circular. The outer ones are all much larger and the eccentricities of all are small.

The inner and large satellites all have small eccentricities, the outer, small satellites of *Jupiter* and *Saturn* have large eccentricities.

If the fainter asteroids are also, in general, the smaller then there is evidence of such a dependence among them.

The comets appear to be striking examples of such a dependence. Their masses are negligible and the eccentricities of all but a comparatively few of short period are essentially unity.

The dependence of orbital eccentricity upon length of period in binary stars, first noted by Doberck, is not a linear function of the length of period, but has a more or less abrupt change at periods of 15 to 20 days. The systems with periods longer than this up to 194

Table IV

Satellites*

		Eccentricity	Diameter km.
Mars			
	Phobos	0	56?
	Deimos	0	16?
Jupiter			
	5	?	160
	1	0	4000
	2	0	3360
	3	0.001	5680
	4	.007	4740
	6	.16	160?
	7	.12	65?
	8	.35	Small
	9	.11	Small
Saturn			
	1	0	1000?
	2	0	1300?
	3	0	1900?
	4	0	1800?
	5	0	2400?
	6	0.030	5600?
	7	.119	800?
	8	.030	3200?
	9	.22	80?
Uranus			
	1	0	800?
	2	0	600?
	3	0	1600?
	4	0	1300?
Neptune			
	1	0	3200?

*Taken chiefly from Young's *General Astronomy*, Table II.

Table V

Minor Planets*

φ	m_0	g	No.
0° to 5°	12.26	8.69	188
5 to 10	12.34	8.83	347
10 to 15	12.25	8.93	230
15 to 20	12.64	9.29	42
20 to 33	11.0	10.57	9

*From *Vierteljahrsschrift der Astronomischen Gesellschaft*, 1918.

years, both spectroscopic and visual binaries, show essentially the same range and distribution as to eccentricity. The systems with periods shorter than about 15 days contain no very large eccentricities and a larger proportion of nearly circular orbits.

There appear also to be some indications of a dependence of eccentricity upon the total masses of the systems, those with large masses having a tendency to the smaller eccentricities. This deduction requires confirmation from more extensive data.

The dependence of orbital eccentricity upon relative mass of the components is not consistently shown in individual cases but appears as a residual effect when a considerable number of stars are concerned much as the dependences of radial velocity and proper-motion upon spectral type, the relation of radial velocity to proper-motion, star streaming, etc.

Such a dependence undoubtedly points to some important fact or condition in the history of these bodies. The explanation must for the present, however, be a matter of conjecture. The most obvious and indeed the only explanation of such a dependence which occurs to me is that it may be a residual effect of capture.

Decreasing eccentricities with increasing masses of the systems suggests growth by the accumulation of external matter.

See in Vol. II of his "Evolution of Stellar Systems", pp. 383, 391 in particular, in discussing his "Capture Theory of the Solar System," points out the high eccentricities of the retrograde satellites of *Jupiter* and *Saturn* as evidence favoring that theory. He also points out that upon such a theory the orbits of all of the secondary bodies of the system must have been very eccentric immediately after capture and that accumulation subsequently reduced such eccentricities. He does not appear, as far as I can find, to have recognized the corollary that capture would in general lead to a dependence of eccentricity upon the relative masses of the components.

Moulton in his "Introduction to Astronomy" (p. 475-6) in discussing the effect of collisions as effecting the Planetesimal or Spiral Hypothesis remarks upon the larger eccentricities of the smaller of the major planets and upon the larger average eccentricities of the minor planets as a class. I have not been able to find any specific recognition or discussion of a relation between eccentricity and relative mass.

The effects of a resisting medium have been recognized and discussed from the times of Euler and Laplace and would be to decrease the eccentricities as well as the mean distances and periodic times. Investigators appear to have dealt only with the general effects of a resisting medium and not to have treated the special cases here arising.

Whether or not such a dependence of orbital eccentricity upon relative mass as that observed would result from the action of a resisting medium alone depends upon the initial eccentricities and masses obtaining in multiple systems. If originally such systems were of all orbital eccentricities and relative masses such a dependence would not be likely to result. In fact it can be shown that a dependence of an opposite kind might be expected to develop in such a case. If, however, the initial conditions were essentially the same as to eccentricity and relative mass variable effects of a resisting medium would produce such a dependence.

We do not know of course what the initial condition as to orbital eccentricity was but if the action of a resisting medium can be postulated, as seems not improbable, it appears necessary to conclude that originally the eccentricities could not have been fortuitous but that the systems with the smallest secondaries had not only the highest eccentricities but higher in general, very much higher perhaps, than we find at present. Taken in connection with the rather definite evidence which is accumulating of cosmical matter in our stellar system and in the spiral nebulæ such a dependence may have a not unimportant bearing on the question not only of the origin of the Solar System but of stellar systems as well.

In this connection it is perhaps permissible to refer briefly to some of the theories of cosmogony and to recently discovered facts which affect them.

The stellar binary systems have generally been assumed to originate by fission.

The old Laplacian nebular ring hypothesis to account for the origin of the Solar System has failed to satisfy so many important requirements when carefully examined that it is difficult to see how it can be accepted in any form. Chamberlin and Moulton who have given the matter of the evolution of the Solar System the greatest attention in recent years, found it necessary to abandon that theory entirely. They have sought a more satisfactory explanation and have based their Planetesimal Hypothesis largely upon the widespread spiral motion in the nebulæ disclosed by the work of Keeler*.

See proposed direct capture for the bodies of the Solar System but retains the theory of fission for double stars.†

* *Astrophysical Journal*, 22, 165, 1905.

† *Evolution of Stellar Systems*, Vol. 2, pp. 14, 357, 581, 1910.

Lockyer's meteoritic hypothesis is perhaps the best known and most extreme example of the suggestions that finely divided solid matter has played an important part in the evolution of the heavenly bodies.

The very high radial velocities of the spiral nebulæ which have recently come to light and their presumably large masses are difficult to harmonize with the planetesimal hypothesis. The great number of these bodies indicates the importance of this type of motion, but high radial velocities and large masses are difficult to explain on the assumption that they have been originated by the near approach of two stars. If formed in this way the masses would be of the order of stellar masses and the radial velocities should be, in all probability, of a similar order.

The high radial velocities, unusual forms and probable large masses of the spirals, notwithstanding their seeming peculiar negative relation to the galaxy, differentiate them sharply from the stars. Whether they are true Stellar Universes like ours is not certain altho their spectra and the appearance of many novæ in them tend in that direction. If they are found to have systematically large motions of recession from our stellar system in all directions it will be difficult to conceive of them as independent systems. It is not impossible, however, to conceive of systems which are very much smaller than our stellar system yet large enough and with the attributes to furnish novæ phenomena — that spiral nebulæ may not necessarily be autonomous. It is perhaps significant that their velocities are of the order which would be necessary to drive streams of matter permanently away from the larger stars.

Taking all things into account it may be doubted that there is any great similarity between the Solar System and the spiral nebulæ beyond the community of matter existing throughout the known universe. The development and changes of orbits from the original motions within a spiral in the planetesimal hypothesis have not been worked out as far as I know. It is therefore impossible to say whether a dependence of orbital eccentricity upon relative mass would be a consequence of that theory or not. Such a dependence could scarcely result from the Laplacian ring theory.

There seems no reason to doubt that higher eccentricities in systems with the smaller secondaries would be a consequence of pure capture originally, either of bodies of very small mass or appreciable size.

Further confirmation and discussion of this dependence as well as its importance must be left to the future.

Observatorio Nacional Argentino,
Córdoba, December 31. 1920.

ELEMENTS OF THE *PONS-WINNECKE* COMET.

By F. E. SEAGRAVE.

The elements, constants and anomalies of the *Pons-Winnecke* Comet, as given below, are based upon three observations made by Prof. Barnard of the Yerkes Observatory on April 12, May 7 and May 31, 1921. The periodic time based upon these elements is 2185.909 days.

E = May 31.7535 G. M. T. 1921
$M = 357° 59' 48''.71$
$\omega = 170° 17' 18''.07$
$\pi = 268° 23' 46''.87$
$\Omega = 98° 6' 28''.80$
$i = 18° 54' 36''.84$

$\log e = 9.8352121$
$\log a = 0.5180224$
$\log q = 0.0173717$
$\mu = 592''.888$
$x = r(9.9764102) \sin (188° 33' 50''.03 + u)$
$y = r(9.9742350) \sin (105° 28' 10''.66 + u)$
$z = r(9.6660434) \sin (58° 12' 2''.56 + u)$

Geocentric

t = April 12.6458 $\lambda = 223° 59' 35''.65$ $\beta = +56° 1' 53''.59$
t' = May 7.7928 $\lambda' = 249° 34' 54''.32$ $\beta = +68° 9' 4''.05$
t'' = May 31.7535 $\lambda'' = 323° 6' 28''.06$ $\beta = +56° 37' 53''.99$

Heliocentric

$$l = 207^\circ\ 13'\ 13''.86 \quad b = +17^\circ\ 56'\ 10''.89 \quad \log r\ \ 0.1232763$$
$$l' = 229^\circ\ 23'\ 56''.44 \quad b' = +14^\circ\ 26'\ \ 4''.49 \quad \log r'\ \ 0.0619951$$
$$l'' = 255^\circ\ \ 2'\ 24''.33 \quad b'' = +\ 7^\circ\ 38'\ 42''.11 \quad \log r''\ \ 0.0230472$$

True Anomalies — Eccentric Anomalies

$$u = 108^\circ\ \ 9'\ \ 1''.17 \qquad v = 297^\circ\ 51'\ 43''.10 \qquad E = 330^\circ\ 45'\ 28''.36$$
$$u' = 129^\circ\ 43'\ 16''.50 \qquad v' = 319^\circ\ 25'\ 58''.43 \qquad E' = 341^\circ\ 49'\ \ 0''.22$$
$$u'' = 155^\circ\ 45'\ 50''.74 \qquad v'' = 345^\circ\ 28'\ 32''.67 \qquad E'' = 353^\circ\ 41'\ \ 1''.46$$

Mean Anomalies

$$M = 349^\circ\ 54'\ 33''.36 \qquad z' = 55^\circ\ 16'\ 27''.00$$
$$M' = 354^\circ\ \ 3'\ \ 2''.70 \qquad \log p = 0.2437770$$
$$M'' = 357^\circ\ 59'\ 48''.71$$

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN. WITH A $4\frac{1}{2}$ INCH REFRACTOR,

By A. W. QUIMBY.

1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1921	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs	Def.
Jan. 1	8	1	4	10	2	fair	Jan. 28	8	–	1	3	1	fair	Feb. 21	9	–	2	5	1	fair
2	9	–	2	16	1	fair	29	8	–	1	1	2	fair	25	8	–	1	3	1	fair
3	8	–	2	10	1	fair	30	12	1	2	2	2	fair	26	8	1	1	1	1	fair
4	8	–	2	15	2	fair	Feb. 1	8	–	1	3	1	fair	28	10		1	2	1	fair
5	9	–	1	12	3	fair	2	4	–	1	5	1	fair	Mar. 1	8	–	1	4	1	fair
6	8	–	1	12	1	fair	3	10	–	1	7	1	fair	2	8	–	1	2	–	fair
7	9	–	1	10	–	fair	4	9	–	1	12	–	fair	3	4	–	–	—	–	fair
8	4	1	2	4	1	fair	5	8	–	1	5		poor	4	8	–	–	—	1	fair
10	8	–	1	3	1	poor	6	9	1	2	8	1	fair	5	8	–		—	–	fair
11	8	1	2	20	–	fair	7	8	–	2	7	1	fair	6	8	–		—	–	fair
12	8	–	2	20	–	poor	8	8	–	2	7	–	fair	7	4	–	–	—	–	fair
13	9	2	4	37	1	fair	10	10	–	2	2	–	poor	8	10	1	1	4	1	fair
15	8		4	29	1	fair	11	8		2	2	–	poor	9	8	–	1	4	1	fair
16	8	–	2	28	1	fair	12	4	1	1	2	5	fair	10	8	–	1	5	–	fair
17	8	–	2	20		poor	13	8	2	3	7	2	fair	11	7	1	2	16	1	fair
18	8	–	2	20	–	poor	14	8	–	3	3	1	fair	12	8	2	1	26	1	fair
19	8	–	2	8	–	poor	15	8		3	3	1	fair	13	8	–	3	7	1	fair
20	12	1	2	5	1	fair	16	8	–	2	2	2	fair	14	7	–	3	7	1	fair
21	10	1	3	12	2	fair	17	4		2	11	1	fair	15	7		3	7		fair
23	8	–	2	11	3	fair	18	4	–	1	15	1	fair	16	5	1	3	4	1	fair
24	8	–	2	5	1	fair	19	11	–	1	15	1	fair	17	7		2	2	–	fair
25	8	1	2	4	1	fair	21	8	–	1	20	1	fair	18	7	–	2	2	–	fair
26	8	–	1	2	–	fair	22	8	1	2	21	1	fair	19	7	–	2	2	–	fair
27	10	1	2	7	1	fair	23	1	–	2	10	1	fair	20	7	–	1	1	–	fair

1921	Time	New Grs	Total Grs	Total Spots	Fac Grs	Def.
Mar. 21	7	1	2	3	1	fair
22	5	–	2	7	2	good
23	7		1	7	1	fair
25	7	1	2	19	1	fair
26	5		2	17	–	fair
27	7	2	4	23	1	good
28	7	–	3	17	–	fair
29	5	1	3	9	1	fair
30	7	–	3	8	1	good
31	12	–	3	3	–	poor
Apr. 1	5	–	3	3	1	good
2	7	–	3	3	1	good
3	5	1	3	10	1	good
4	7	–	2	10	1	good
5	5	1	2	8	1	good
6	5		2	9	1	fair
8	12		2	11	1	fair
9	10		1	6	–	poor
10	7	1	2	5	1	fair
11	3	–	2	11	1	fair
12	5	–	2	14	1	fair
13	7	–	2	7	1	fair
14	7	–	2	5	1	fair
15	6	2	4	14	1	fair
16	3	1	3	17	1	fair
17	12	1	4	23	3	fair
18	12	–	4	20	2	fair
19	5	1	5	11	3	fair
20	7	–	5	16	2	fair
21	7	–	3	10	2	fair
22	12	–	2	2		poor
23	12	–	2	10	1	fair
Apr. 24	7	–	2	9	–	fair
25	7	–	2	7	–	fair
26	7	–	2	8	1	fair
27	7	–	2	4	2	fair
28	6	–	1	1	1	fair
29	10	–	–	—	–	poor
May 1	12	–	–	—	–	fair
2	7	1	1	4	1	fair
3	7	–	1	4	1	fair
6	10		–	—		poor
7	7	–	–	—	2	fair
8	6	1	1	12	3	fair
9	6	–	1	22	2	fair
10	7	–	1	30	1	fair
11	7	–	1	34	3	fair
13	6	1	2	40	1	fair
14	10	–	1	34		fair
15	6	–	1	22		fair
16	6	–	1	20	–	fair
17	6	–	1	14	1	fair
18	7	–	1	13	1	fair
19	7	1	2	13	2	fair
20	6	1	3	6	2	fair
21	6	–	3	4	2	fair
22	7	–	1	4	–	fair
23	7	–	1	4		fair
24	7	–	1	3	–	fair
25	4	–	1	1		fair
26	7	–	1	1	–	fair
27	7	–	1	1	–	fair
28	7	1	1	1	1	fair
29	5	1	2	4	2	fair
May 30	5	–	2	3	1	fair
31	7	–	1	1	–	fair
June 1	7	1	2	4	2	fair
2	6	–	2	7	1	fair
3	7	–	1	10	1	fair
4	7	1	2	11	1	fair
5	7	–	2	7	1	fair
6	7	–	2	11	1	fair
7	7	–	2	10	1	fair
8	8	2	4	17	2	fair
9	6	1	5	30	1	fair
10	6	–	3	30	–	fair
11	6	–	2	27	–	fair
12	6	–	2	8	–	fair
13	6	1	2	12	1	fair
14	6	–	1	4	1	fair
15	6	–	1	2	1	fair
17	6	1	1	1	1	fair
18	6	–	1	1	1	fair
19	6	–	1	4	1	fair
20	6	–	1	1	1	fair
21	6	–	1	2	1	fair
22	6	–	1	3	–	fair
23	6	1	2	5	1	fair
24	6	1	3	3	2	fair
25	6	1	4	7	2	fair
26	16	–	4	5	1	poor
27	7		4	12	2	fair
28	6	–	3	37	1	fair
29	6	–	2	44	1	fair

NOTICE

With the completion of the next two numbers of the *Astronomical Journal* subscription will be due for Volume XXXIV. The subscription price will continue, as in the past, at $5.00 net the volume. It is suggested that subscribers deal directly with the *Journal*, when possible, as considerable confusion has arisen where subscriptions have been handled by agencies.

Benjamin Boss, *Editor*.

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OBSERVATIONS MÈRIDIENNES DE LA *LUNE* ET DE PLANÈTES,

FAITES À L'OBSERVATOIRE DE BESANÇON, AU CERCLE MÈRIDIÉN P. GAUTIER,

PAR M. M. BRÜCK (B.) ET L. PERROT (L. P.).

Dates	Obsr.	T_m Besancon	Bord.	AR Apparente	O — C Newcomb	Bord.	D.P. Apparente	O — C Newcomb	Observations
				Lune					
1909		h m s		h m s	s		° ′ ″	″	
Mars 1	L. P.	8 18 23.73	1	6 54 17.36	+0.54	S	65 26 13.6	+ 5.9	
5	L. P.	11 31 18.34	1	10 23 29.88	0.63	S	74 54 30.6	+ 0.7	
Avril 2	L. P.	10 12 48.95	1	10 55 11.08	0.60	S	77 43 1.0	+ 8.2	
3	L. P.	10 54 16.34	1	11 40 41.83	0.38	S	82 26 17.1	+ 1.2	
5	L. P.	12 15 18.95	1	13 9 50.93	0.65	S	92 37 28.3	+ 6.5	
5	L. P.	....	2	9 50.78	0.50	.	....	...	
6	L. P.	12 56 33.54	2	55 8.78	0.54	S	97 43 47.2	+ 1.6	
Mai 3	L. P.	10 54 33.71	1	13 39 13.87	0.51	S	95 56 42.3	+ 2.3	
4	L. P.	11 36 59.27	1	14 25 14.96	0.46	S	100 59 0.6	+ 1.2	
5	L. P.	12 21 47.82	2	15 14 37.43	0.53	S	105 38 33.0	+ 4.1	
6	L. P.	13 9 37.90	2	16 6 31.92	0.53	S	109 39 44.6	+ 0.6	
Juin 1	L. P.	10 16 30.87	1	14 55 26.91	0.81	S	103 52 41.0	+ 1.1	
Nov. 26	L. P.	11 24 45.44	1	3 45 39.59	+0.37	I	70 58 46.6	− 0.1	
1911									
Avril 11	L. P.	10 54 50.62	1	12 10 54.40	+0.46	S	87 36 47.4	− 4.0	
14	L. P.	13 1 49.40	2	14 36 3.71	0.57	I	104 47 30.9	− 7.6	
Juin 7	L. P.	8 58 24.64	1	13 58 53.00	0.64	S	101 21 35.0	− 1.7	
10	L. P.	11 12 33.62	1	16 25 13.70	0.53	S	114 12 3.4	− 2.0	
Juill. 11	L. P.	12 31 1.61	2	19 46 7.88	0.48	I	116 10 18.6	−10.7	
1912									
Mars 29	L. P.	9 43 1.36	1	10 10 37.70	+0.10	S	74 15 36.4	+ 2.8	
30	L. P.	10 33 42.46	1	11 5 23.68	0.66	S	80 39 18.6	+ 5.5	
Avril 2	L. P.	12 54 49.55	2	13 38 43.62	0.52	I	100 47 30.1	+ 4.7	
3	L. P.	13 42 2.83	2	14 30 1.20	0.70	I	106 36 26.9	+ 0.8	
4	L. P.	14 30 45.17	2	15 22 48.16	0.58	I	111 28 46.2	+ 2.4	
Mai 1	L. P.	12 21 17.40	2	14 59 26.04	0.62	I	109 27 28.8	+ 5.3	
3	L. P.	14 2 42.52	2	16 49 0.94	0.67	I	116 38 51.1	− 3.1	
Juin 28	L. P.	11 34 8.0	.	....	...	I	118 12 35.6	+ 3.1	
Dec. 4	B.	21 3 1.63	2	13 58 8.71	+0.31	.	....	.....	
17	B.	6 37 18.09	1	0 21 18.23	0.51	I	88 1 31.1	− 4.5	

Dates	Obs.	Tm Besançon	Bord.	AR Apparente	O — C Newcomb	Bord.	D.P. Apparente	O — C Newcomb	Observations
				Lune (Continued)					
1912		h m s		h m s	s		° ′ ″	″	
Dec. 19	B.	8 2 17.98	1	1 54 25.19	0.63	I	76 12 54.1	− 3.7	....
20	L. P.	8 50 19.73	1	2 46 31.39	+0.76	I	70 49 19.2	− 0.2	....
21	L. P.	9 43 41.32	.	3 43 58.30	0.86	I	66 15 19.5	−18.4	....
23	L. P.	11 46 29.48		5 54 59.76	0.84	S	61 37 17.8	+ 2.3	....
30	L. P.	18 14 36.79	2	12 51 46.75	0.56	I	96 10 32.2	+ 6.5	....
1913									
Jan. 2	B.	20 38 34.83	2	15 27 58.11	+0.30	.	....	.....	....
17	L. P.	7 28 33.20	1	3 14 55.08	+0.87	I	68 8 43.1	+ 6.0	....
24	L. P.	14 30 32.73	2	10 45 39.84	0.55	I	79 43 32.1	+12.4	....
Fev. 10	B.	3 11 25.69	1	0 31 42.70	0.74	.	....	.....	....
11	B.	3 51 36.91	1	1 15 57.07	0.84		....	.....	....
12	B.	4 34 8.51	1	2 2 32.21	0.81	I	74 45 45.7	− 2.5	....
13	B.	5 20 15.39	1	2 52 43.23	0.90	I	69 45 29.4	−12.9	....
14	B.	6 11 3.56	1	3 47 36.30	0.97	I	65 35 38.9	− 3.2	....
15	B.	7 7 7.11	1	4 47 45.62	0.98	I	62 39 30.9	+ 2.5	....
17	L. P.	9 11 29.21	1	7 0 21.25	0.97	S	62 7 28.2	− 0.5	....
18	L. P.	10 14 58.05	1	8 7 57.07	0.68	S	64 59 16.1	+ 0.4	....
20	L. P.	12 12 58.04	1	10 14 9.56	0.57	S	76 1 17.3	+ 1.5	....
21	L. P.	13 6 31.57	2	11 11 48.45	0.55	I	83 9 33.7	+ 8.5	....
22	L. P.	13 57 33.81	2	12 6 55.62	0.48	I	90 36 11.6	+ 4.4	....
23	L. P.	14 47 24.72	2	13 0 51.28	0.38	I	97 50 34.1	+ 7.2	....
24	L. P.	15 37 21.20	2	13 54 52.51	0.46	I	104 26 43.0	+10.1	....
25	L. P.	16 28 22.31	2	14 49 58.56	0.45	I	110 3 28.2	+ 2.9	....
Mars 13	B.	4 5 55.93	1	3 28 35.08	1.08	I	66 45 47.4	− 1.8	....
15	B.	5 56 20.90	1	5 27 11.30	1.05	I	61 32 56.4	− 1.0	....
16	B.	6 56 49.37	1	6 31 46.25	1.16	S	61 27 44.8	+ 2.8	....
18	L. P.	8 58 12.29	1	8 41 22.22	+0.29	S	67 8 23.7	+ 6.5	....
27	L. P.	17 0 17.18	2	17 20 15.28	+0.66	I	118 19 57.5	+ 3.5	....
Avril 15	L. P.	7 44 48.46	1	9 18 9.85	1.02	S	70 13 50.3	+ 4.4	....
24	L. P.	15 43 27.78	2	17 53 36.80	0.73	I	118 38 40.3	+ 3.4	....
26	L. P.	17 32 2.40	2	19 50 22.36	0.63	I	115 26 44.3	− 7.3	....
28	L. P.	19 6 9.0	.	....	.....	S	108 20 39.4	− 1.7	....
Mai 20	L. P.	12 30 35.20	2	16 22 42.99	0.61	I	116 18 19.4	+ 5.4	....
21	L. P.	13 28 39.17	2	17 24 53.06	0.76	I	118 13 50.1	+ 5.6	....
Juin 15	L. P.	9 25 0.96	1	14 59 8.78	0.92	S	110 57 1.5	+ 4.1	....
16	L. P.	10 19 31.78	1	15 57 45.11	0.77	S	115 3 29.9	+ 4.3	....
17	L. P.	11 16 22.05	1	16 58 41.28	0.65	S	117 37 7.7	+ 6.2	....
Juill. 15	L. P.	10 5 41.68	1	17 38 12.94	0.97	.	....	.....	....
Oct. 10	L. P.	8 53 10.12	1	22 8 29.76	0.87	I	103 50 9.5	− 4.5	....
11	L. P.	9 33 33.12	1	22 52 55.95	0.82	I	98 23 30.3	− 3.6	....
13	L. P.	10 51 20.80	1	0 18 49.42	0.81	I	86 49.16 0	− 5.7	....
14	L. P.	11 30 50.94	1	1 2 22.70	0.55	I	81 3 44.0	− 3.4	....
	..	....		.. ..	.....	S	.. 3 43.3	− 4.1	....
16	L. P.	12 56 10.09	2	2 35 18.97	0.54	S	70 36 52.1	− 9.8	....
17	L. P.	13 43 41.88	2	3 27 25.12	0.84	S	66 26 3.1	− 1.5	....
18	L. P.	14 35 3.29	2	4 22 51.53	0.78	S	63 20 15.0	+ 0.3	....

Dates	Obsr.	Tm Besançon	Bord.	AR Apparente	O − C Newcomb	Bord.	D.P Apparente	O − C Newcomb	Observations
				Lune (Continued)					
1913		h m s		h m s	s		° ′ ″	″	
Nov. 10	L. P.	9 28 43.87	1	0 46 22.57	+0.57	I	83 4 13.3	− 5.1	
Dec. 8	L. P.	8 4 47.90	1	1 12 36.45	0.79	I	79 32 1.3	− 3.8	
9	L. P.	8 46 54.68	1	1 58 46.68	0.86	I	74 12 43.6	− 1.2	
13	L. P.	12 13 15.0	.	....	..	S	61 38 57.9	+ 0.2	
1914									
Jan. 8	L. P.	9 2 44.68	1	4 12 56.06	+0.97	I	63 45 11.0	− 1.4	
Feb. 5	L. P.	7 43 38.5	.	....	....	I	62 25 48.9	− 2.3	
6	L. P.	8 40 29.82	1	5 44 57.71	+0.97	S	61 28 3.2	+ 0.3	
9	L. P.	11 36 34.45	1	8 53 20.91	+0.82	S	69 21 26.1	+ 2.7	
Mars 11	L. P.	11 59 34.98	1	11 14 41.94	+0.77	I	85 25 11.3	+ 9.6	
..	L. P.	....	2	14 41.83	+0.66	S	.. 25 6.4	+ 4.7	
Avril 9	L. P.	11 26 12.22	1	12 35 33.71	+0.66	S	96 19 10.6	+ 4.0	
10	L. P.	12 19 40.06	2	13 33 6.88	0.61	I	103 27 59.2	+ 6.6	
Juin 9	L. P.	13 46 56.45	2	18 57 11.00	0.80	I	117 6 55.3	+ 3.2	

Dates	Tm Besançon	AR Apparente	Correct. d' éphém. C. d. T.	D P. Apparente	Correct. d' éphém. C. d. T.	Diamètre Vert.	Diamètre Horiz.	Observations
				Mars				
1909	h m s	h m s	s	° ′ ″	″	s	″	
Oct. 7	10 52 26.76	23 56 7.84	−0.44	94 45 50.6	+ 3.8	1.59	25.65	
11	33 30.80	52 54.98	0.44	46 24.8	3.0	1.57	25.10	
14	19 45.53	50 57.11	0.35	13 43.0	2.8	1.55	24.20	
15	15 15.84	50 23.24	0.44	42 11.9	2.1	1.50	23.38	
18	10 2 4.40	48 59.30	0.38	35 52.2	3.3	1.49	22.68	
19	9 57 46.43	48 37.17	0.44	33 8.1	2.7	1.42	23.15	
20	53 31.55	48 18.14	0.40	30 7.2	3.1	1.44	21.80	
22	45 10.70	47 49.03	0.43	23 10.8	2.6	1.41	21.50	
Nov. 4	8 55 40.84	49 26.26	0.84	93 11 46.3	1.8	1.25	20.13	
5	52 11.79	49 53.19	0.88	4 35.7	2.4	1.31	19.34	
9	38 41.23	52 6.64	−1.04	92 33 42.1	+ 2.3	1.12	18.85	
1914								
Jan. 13	11 21 8.75	6 51 25.65	−0.20	63 1 50.7	− 3.1	1.12	..	B I seul observé
19	10 48 35.06	42 25.97	0.16	62 52 18.3	2.6	1.19	.	B I
22	32 53.11	38 31.11	0.23	49 56.1	1.8	1.21	17.05	
23	27 45.19	37 18.90	0.21	19 27.8	1.6	1.17	16.97	
24	22 40.48	36 9.92	0.17	49 8.7	1.2	1.09	16.90	
26	10 12 40.92	34 1.83	0.16	48 55.4	1.1	1.12	16.03	
30	9 13 23.20	30 27.17	0.17	49 59.3	1.5	1.13	17.02	
31	48 42.73	29 42.49	0.08	50 31.8	1.8	1.07	15.30	
Feb. 2	39 32.37	28 23.73	0.17	51 56.1	0.9	1.07	15.73	
3	35 2.65	27 49.84	0.15	52 45.7	1.0	1.11	16.00	
6	21 55.05	26 29.75	0.15	55 43.7	− 0.7	1.13	16.05	

Dates	Tm Besancon	AR Apparente	Correct. d' éphém. C. d. T.	D. P. Apparente	Correct. d' éphém. C. d. T.	Diamétre Vert.	Diamétre Horiz.	Observations
				Jupiter				
1909	h m s	h m s	s	° ′ ″	″	s	″	
Feb. 19	12 53 42.77	10 50 56.09	+0.10	81 10 32.4	− 2.7	3.09	45.86	. . . .
Mars 5	11 51 54.12	44 9.05	.05	80 28 19.3	0.8	3.15	44.63	. . . .
9	34 15.39	42 13.63	.06	16 39.7	1.3	3.09	45.27	. . . .
17	10 59 7.36	38 32.25	.05	79 54 45.2	1.1	3.14	44.80	. . . . . .
19	50 23.26	37 39.82	.09	49 38.1	1.7	3.08	44.43	. . . . . .
Avril 2	9 50 2.34	32 20.73	.05	19 28.0	2.0	3.02	44.00	. . . .
3	46 47.36	32 1.77	.03	17 44.9	1.3	2.92	43.48	. . . .
5	37 19.70	31 25.66	.09	14 27.7	2.1	3.00	43.30	. . . .
6	33 6.58	31 8.40	.03	12 55.7	1.5	2.98	42.60	
7	28 54.08	30 51.77	.00	11 26.8	1.7	3.01	42.83	. . . .
8	24 42.29	30 35.84	.05	10 1.6	1.9	3.03	42.47	
9	20 31.01	30 20.42	.00	8 40.6	1.9	2.97	42.43	. . . .
16	8 51 30.20	. . . .	. . .	1 2.1	3.8	. . .	41.55	. . . .
17	47 24.17	28 10.57	−0.01	79 0 14.3	2.6	2.93	41.65	. . . .
20	35 10.16	28 14.21	+0.05	78 58 12.4	1.7	2.94	41.90	. . . .
21	31 6.85	28 6.79	.07	57 39.1	2.4	2.95	42.60	
23	23 2.22	7 53.95	.00	56 47.4	1.3	2.81	40.40	
28	8 3 3.03	10 27 34.24	0.05	78 55 48.1	− 1.2	2.76	40.75	. . . .
1911								
Avril 14	13 10 28.77	14 38 41.50	+0.21	104 0 14.8	− 0.4	3.13	43.70	. . . .
Juin 3	9 31 20.99	16 8.53	0.20	102 15 50.5	− 0.8	2.94	44.02	. . . .
Juin 7	9 14 24.64	14 14 55.63	0.22	. . . .	. . . . .	3.08	. . . .	
10	1 48.57	14 7.16	0.17	102 7 10.6	− 0.6	2.82	41.80	
1913								
Juill. 25	10 33 32.09	18 45 33.49	0.36	113 10 58.7	+ 0.3	3.51	46.30	
28	20 20.70	44 9.61	0.45	12 50.6	− 0.4	3.48	46.20	. . . . . .
29	15 57.90	43 42.65	+0.52	13 27.0	+ 0.1	3.60	. . . .	B I seul
				Saturne				
1909								
Oct. 14	11 45 24.33	1 16 49.98	−1.01	84 52 55.2	+ 5.8	1.36	20.55	. . . . . .
15	41 10.77	16 32.28	1.02	54 42.3	6.2	1.40	20.80	. . . .
19	24 16.83	15 21.78	1.04	85 1 43.9	6.0	1.35	20.08	. . . .
20	20 3.44	15 4.25	1.06	3 28.9	7.0	1.32	20.80	. . . . . .
22	11 36.88	14 29.41	1.09	6 53.8	6.4	1.40	21.60	image peu nette
Nov. 4	10 16 55.80	10 54.56	1.04	27 27.5	6.1	1.36	20.55	. . . .
5	12 44.63	10 39.26	0.94	28 53.6	6.5	1.37	21.70	trouble, vent fort
9	9 56 1.70	9 39.81	0.98	34 20.7	6.9	1.31	20.32	. . . .
26	8 45 17.62	1 6 15.65	−1.00	85 51 42.5	+ 6.1	1.31	19.67	. . . .
1913								
Jan. 7	8 36 2.36	3 43 9.74	+0.17	72 23 54.8	+ 0.3	1.48	. . .	B I seul observable
Dec. 8	11 15 20.50	4 53 45.26	0.08	69 9 45.3	+ 0.5	1.54	. . .	B I . . . .
19	16 58 18.95	19 58.13	0.15	14 12.0	− 0.5	1.59	. . .	B I mauvaise image
20	10 54 3.07	49 38.10	0.11	15 8.6	+ 0.6	1.55	. . .	B I . . . .

Dates	Tm Besancon	AR Apparente	Correct. d' éphém. C. d. T.	D. P. Apparente	Correct. d' éphém. C. d. T.	Diamètre Vert.	Diamètre Horiz.	Observations
				Saturne (Continued)				
1913	h m s	h m s	s	° ′ ″	″	s		
Dec. 23	10 41 16.50	4 48 39.11	+0.12	69 16 22.8	+ 0.2	1.61		B I
30	11 35.07	. . . .	. . . . .	19 0.5	− 0.6	.		B I
1914								
Jan. 13	9 13 54.67	4 43 50.67	+0.17	69 22 51.7	+ 0.3	1.51		B I
16	9 0 29.57	42 13.05	0.23	23 22.3	0.0	1.47		B I
Jan. 20	8 44 1.29	41 28.29	0.10	23 51.5	− 0.6	1.50		B I
23	31 44.59	. . . . .	.	24 5.3	− 0.1			B I
24	27 39.86	40 50.41	0.07	24 7.8	− 0.2	1.46		B I
26	19 32.82	40 34.14	0.08	24 10.6	0.0	1.51		B I
30	8 3 21.16	40 7.05	0.11	24 4.1	− 0.1	1.56		B I
31	7 59 19.61	40 1.40	0.09	24 1.3	+ 0.7	1.50		B I
Feb. 2	51 18.11	39 51.69	0.22	23 50.8	+ 0.6	1.51		B I
3	47 17.87	39 47.36	0.10	23 43.7	+ 0.2	1.45		B I
6	35 20.36	4 39 37.55	+0.09	69 23 17.5	− 9.2	1.48		B I
				Uranus				
1909								
Juill. 20	11 29 8.58	19 21 27.89	−0.19	112 36 35.6	+ 1.2			
21	25 2.57	21 17.77	0.15	36 55.5	1.2			
22	20 56.50	21 7.58	0.23	37 15.1	1.0			
Août 23	9 10 29.49	16 28.91	0.16	45 50.6	0.6			
24	6 26.90	19 16 22.22	−0.23	112 46 2.3	+ 0.9			
				Neptune				
1909								
Jan. 18	11 15 33.80	7 6 21.22	−0.54	68 12 24.1	+ 2.7			
19	11 30.85	6 14.16	0.60	12 10.9	1.7			
20	7 28.01	6 7.22	0.57	11 58.9	1.8			
21	3 25.18	6 0.27	0.59	11 46.5	1.5			
26	10 43 11.81	5 26.37	0.58	10 47.8	2.2			
28	35 6.91	5 13.25	0.52	10 24.3	1.9			
29	31 4.41	5 6.65	0.63	10 12.8	1.9			
Feb. 13	9 36 38.01	3 38.65	0.51	7 34.5	2.5			
16	18 35.11	3 23.13	0.58	7 6.5	2.8			
17	14 34.34	3 18.56	0.61	6 58.1	3.5			
18	10 33.77	3 13.88	0.56	6 17.4	1.7			
19	6 33.25	3 9.26	0.56	6 38.8	1.9			
22	8 54 32.27	2 55.97	0.67	6 14.0	2.6			
Mars 1	26 34.62	2 29.60	0.50	5 20.7	2.6			
3	18 36.33	2 23.11	0.54	5 6.2	1.8			
9	7 54 44.72	7 2 6.90	−0.55	68 4 30.9	+ 2.9			
1910								
Jan. 6	12 14 57.14	7 17 38.42	−0.59	68 28 7.6	+ 3.0			
1913								
Jan. 8	12 34 50.34	7 46 33.51	−0.06	69 19 39.6	+ 0.6			
24	11 30 2.72	44 10.18	−0.09	14 41.5	− 0.1			

Dates	Tm Besançon	AR Apparente	Correct. d' éphém. C. d. T.	D P. Apparente	Correct. d' éphém. C. d T.	Diamétre Vert.	Diamétre Horiz.	Observations
			Neptune (Continued)					
1909	h m s	h m s	s	° ′ ″	″			
Feb. 8	10 29 24.19	7 43 0.03	+0.01	69 10 17.2	− 0.5	...	...	....
11	17 17.98	42 41.50	−0.02	9 28.2	− 0.5	...	...	....
12	13 16.04	42 35.45	−0.05	9 12.3	− 0.4	...	...	....
14	5 12.43	42 23.63	−0.07	8 40.2	− 1.1	...	...	....
17	9 53 7.67	42 6.56	−0.06	7 55.3	− 0.4	...	...	....
18	49 6.26	7 42 1.03	−0.07	69 7 40.6	− 0.3	...	...	....
1914								
Feb. 13	10 19 47.48	7 52 7.58	0.00	69 29 31.0	− 0.7	...	...	....
Mars 11	8 35 27.78	50 1.16	−0.04	23 22.5	− 0.7	...	...	....

Dates	Tm Besançon	AR Apparente	Correct. d' éphém. Naut. Alm.	D. P Apparente	Correct. d' éphém. Naut. Alm.	Observations
			Cérès (1)			
1909	h m s	h m s	s	° ′ ″	″	
Juin 14	14 26 50.24	19 57 42.66	+2.56	117 15 29.3	− 1.2	....
Juill. 20	11 35 25.90	27 46.24	2.74	120 27 45.8	+ 1.0	....
21	30 33.94	26 50.04	2.83	120 31 42.7	1.5	....
22	25 42.35	25 54.21	2.84	120 35 33.1	2.6	....
1913						
Mai 20	11 40 17.91	15 32 17.44	+2.90	101 44 16.3	+16.4	....
21	35 26.69	31 21.98	2.87	44 52.3	19.2	....
28	1 40.23	25 5.88	2.87	50 41.7	18.6	....
Juin 4	10 28 27.44	19 23.54	2.63	102 0 17.9	19.7	....
6	19 6.86	17 54.54	2.75	3 45.0	17.7	....
10	0 39.02	15 9.90	2.62	11 48.1	26.2	....
14	9 42 31.30	12 55.43	2.71	21 11.7	19.8	....
15	38 2.56	15 12 12.52	+2.64	23 44.2	18.4	....
16	33 35.2	....	....	102 26 26.6	+21.6	....
			Pallas (2)			
1909						
Juill. 21	9 43 42.84	17 39 41.39	−1.85	68 14 55.0	+ 0.1	....
1913						
Mai 21	10 36 40.29	14 32 25.93	−3.68	64 24 53.6	− 2.6	....
28	5 8.56	28 24.92	3.61	21 47.1	1.4	....
30	9 56 18.28	27 26.31	3.52	23 48.7	2.5	....
Juin 4	34 33.93	25 21.18	3.53	33 59.7	3.3	....
15	8 48 39.48	14 22 41.32	3.21	65 18 55.4	− 4.2	....
1914						
Juill. 18	11 48 33.17	19 32 14.05	−2.00	70 23 13.2	− 3.3	....
			Junon (3)			
1909						
Dec. 13	11 2 20.65	1 30 12.61	−0.49	92 50 38.4	+ 2.4	....
14	10 57 42.69	29 30.41	0.56	48 55.8	1.2	....

Dates	Tm Besancon	AR Apparente	Correct. d' éphém. Naut. Alm.	D. P. Apparente	Correct. d' éphém. Naut. Alm.	Observations
			Junon (3) (Continued)			
1909	h m s	h m s	s	° ′ ″	″	
Dec. 16	10 48 30.09	4 28 9.44	−0.49	92 44 28.0	+ 1.0	
30	9 46 42.13	21 23.16	0.44	91 37 5.1	1.8	
1910						
Jan. 6	9 17 54.76	4 20 6.96	−0.36	90 43 56.0	+ 1.4	
27	8 0 49.98	25 37.23	0.24	87 19 12.9	+ 1.7	
31	7 47 38.58	28 9.89	0.24	86 37 7.2	− 0.2	
1913						
Oct. 10	9 52 0.84	23 7 30.14	−0.16	99 5 38.2	+ 2.0	
11	47 43.66	7 8.82	0.19	13 55.0	3.4	
14	35 1.76	6 14.49	0.07	10 10.7	3.5	
17	22 34.35	5 34.70	0.13	100 4 3.5	2.3	
30	8 31 37.66	23 5 44.86	−0.11	101 18 18.6	+ 2.7	
			Vesta (4)			
1909						
Juin 14	10 37 9.01	16 7 23.70	+1.11	103 57 16.6	+ 4.0	
17	22 58.72	5 0.76	1.08	104 6 22.8	+ 2.6	
19	13 39.19	3 32.81	1.14	104 12 59.2	+ 3.2	
1913						
Juill. 28	12 39 51.0	....	....	112 35 36.9	−15.4	
29	12 34 59.59	21 3 7.18	+3.36	43 29.9	−16.6	

Dates	Tm Besancon	AR Apparente	Correct. d' éphém.	D. P. Apparente	Correct. d' éphém.	Remarques
			Herculina (532)			
1909	h m s	h m s	s	° ′ ″	″	
Mai 24	13 14 56.31	17 22 49.22	− 7.8	97 44 17.3	0.0	Ephèm. I. Chofardet
Juin 1	12 36 19.79	15 38.81	8.2	98 11 44.4	− 1.2	B. A. 1909
7	12 7 3.86	9 57.42	8.6	37 40.1	1.2	....
9	11 57 17.67	8 2.73	8.3	47 15.1	1.1	....
14	11 33 55.01	17 3 19.02	− 9.0	99 13 27.5	− 0.9	....
			Eurynôme (79)			
1909						
Nov. 4	11 52 47.48	2 47 1.99	−4.36	76 33 38.5	+30.7	Ephéméride du Berliner Jahr., de 1911
5	48 1.04	46 11.32	4.12	41 12.5	28.6	
9	28 55.67	42 49.04	3.42	77 11 7.6	22.8	....
			Métis (9)			
1914						
Avr. 15	10 36 40.70	12 9 33.37	.....	82 36 19.3	.....	....
16	32 13.30	9 1.80	.....	35 35.4	.....	....
17	27 34.63	8 18.91	.....	34 10.3	.....	....
18	22 49 11	12 7 29.17	.....	35 21.2	.....	....

Dates	Tm Besancon	AR Apparente	Correct. d' éphém.	D.P. Apparente	Correct. d' éphém	Remarques
			Massalia (20)			
1914	h m s	h m s		° ′ ″		
Avr. 18	11 33 14.47	13 18 6.10	.....	98 16 27.8	.....	....
28	10 44 52.40	9 1.64	.....	97 16 54.5	.....	....
Mai 2	25 26.52	5 18.78	....	96 57 51.2	.....	....

PROPER-MOTIONS OF CERTAIN LONG PERIOD VARIABLE STARS,

By ANNE S. YOUNG and ALICE H. FARNSWORTH.

A list of long period variable stars whose proper-motions had been determined from measures of photographic plates taken with the 24-inch reflector of the Yerkes Observatory was published in No. 784 of this *Journal*. We give now an additional list of ten long period variables whose proper-motions have been found in the same way.

The material given in this table is of the same character as that given there and needs no explanation.

The plates used for *o Ceti*, the brightest variable of this type, were taken with the aperture reduced to 12 inches and were exposed four minutes instead of an hour. Boss* gives for this star a proper-motion of $-0^s.0001$ in right ascension, $-0''.237$ in declination. Least squares solutions were made for *o Ceti* and *U Librae* because of the unequal distribution of the standards.

Grateful acknowledgment is made of the grant received from the American Association for the Advancement of Science which has made it possible for us to secure help in recording and reducing measures.

* *Preliminary General Catalogue.*

Star	R. A. (1900)	Decl. (1900)	Ep.	Int.	No. Stars	μ^a	μ_δ	Resid. in a	Resid. in δ
	h m s	° ′ ″		y		″ s	″		
o Ceti	2 14 17.66	− 3 25 53.5	07.68	13.20	12	+.026 .0018	−.268	2	2
S Aurigae	5 20 30.84	+34 3 44.0	07.87	12.24	25	+.040 .0033	+.014	2	5
U Puppis .	7 56 9.51	−12 33 58.5	08.25	11.88	27	−.016 .0011	−.036	4	2
X Leonis ...	9 54 27.81	+21 44 29.7	08.22	11.98	19	+.021 .0015	+.010	2	7
U Librae ...	15 36 13.62	−20 51 29.5	08.49	11.97	16	+.034 .0024	−.044	6	10
U Serpentis ...	16 2 31.34	+10 11 56.8	08.19	12.27	25	+.002 .0002	+.049	4	8
Y Aquarii	20 39 8.76	− 5 11 42.1	07.76	12.11	27	+.014 .0009	+.035	0	3
T Capricorni .	21 16 29.77	−15 35 2.9	07.76	11.87	18	+.005 .0004	−.013	3	9
U Aquarii	21 57 52.36	−17 6 34.0	07.55	12.33	21	+.001 .0001	+.020	1	6
R Pegasi	23 1 37.63	+10 0 12.7	01.99	19.02	25	−.030 .0020	−.023	2	1

Mount Holyoke College,
June, 1921.

CONTENTS.

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OBSERVATIONS OF COMETS,

MADE WITH THE 40-INCH AND 12-INCH REFRACTORS OF THE YERKES OBSERVATORY,

(Continued from *A. J.*, Nos. 695, 756 and 780)

By GEORGE VAN BIESBROECK.

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Instr.
					Periodic Comet *Tempel* 1920 *a*					
1920	h m s	m s	′ ″		h m s	° ′ ″				
July 20	19 54 13	+0 4.76	+ 3 48.9	6 , 6	1 53 24.68	− 1 17 23.3	9.572*n*	0.778	1	12
21	21 13 38	−0 36.33	− 2 15.0	6 , 6	55 56.07	− 1 19 38.7	9.438*n*	0.781	2	12
22	19 44 30	−0 32.74	− 1 17.2	8 , 8	1 58 9.17	− 1 21 36.0	9.579*n*	0.778	3	12
24	20 40 0	−0 14.42	+ 3 35.8	8 , 8	2 2 50.56	− 1 26 50.0	9.497*n*	0.781	4	12
27	20 40 58	−1 5.11	− 2 12.9	16 , 6	9 27.12	− 1 36 18.7	9.485*n*	0.782	5	40
Aug. 21	21 13 26	−2 11.40	− 7 36.2	20 , 4	2 50 28.22	− 4 9 22.4	9.219*n*	0.802	6	12
Sept. 7	21 15 22	−1 1.67	+ 4 12.6	12 , 6	3 1 43.99	− 6 52 37.8	8.784*n*	0.823	7	40
10	21 3 34	+2 38.61	+ 3 13.2	10 , 4	2 13.11	− 7 23 28.4	8.791*n*	0.826	8	40
11	21 14 35	−0 51.43	− 1 1.8	25 , 5	2 16.72	− 7 34 0.3	8.529*n*	0.828	9	12
14	22 7 1	−1 36.09	− 4 39.4	25 , 5	2 8.65	− 8 5 43.7	8.943	0.832	10	40
18	21 23 41	+0 10.07	− 0 3.8	6 , 6	3 1 17.68	− 8 46 28.0	8.583	0.835	11	40
23	20 37 16	+3 25.16	+ 8 43.8	25 , 5	2 59 12.79	− 9 35 4.0	7.951*n*	0.840	12	40
Oct. 7	20 31 26	−2 15.32	− 2 51.4	25 , 5	48 10.92	−11 28 21.3	9.026	0.849	13	40
12	20 34 47	−0 8.65	− 3 38.2	8 , 8	2 42 51.00	−11 55 15.0	9.201	0.848	14	40
					Comet Taylor-Skjellerup 1920 *c*					
Dec. 17	20 19 46	−0 4.46	+ 2 52.5	6 , 6	9 16 59.59	− 3 0 5.5	9.083*n*	0.796	15	12
19	18 51 57	+0 10.99	+ 2 27.4	8 , 8	26 26.84	− 0 22 15.5	9.432*n*	0.775	16	40
24	0 18 8	+0 18.08	− 1 12.9	6 , 6	9 46 3.21	+ 5 47 45.5	9.466	0.733	17	12
1921 Jan. 2	17 43 27	−0 2.64	− 9 23.0	6 , 6	10 24 48.48	19 10 56.6	9.583*n*	0.645	18	40
3	19 41 16	−0 9.24	+ 7 49.3	6 , 6	28 26.20	20 31 16.3	9.321*n*	0.546	19	12
5	17 6 18	+0 34.61	+ 0 48.8	6 , 6	34 29.62	22 46 18.1	9.630*n*	0.645	20	12
7	18 30 35	−0 54.57	− 6 8.4	6 , 6	40 33.76	25 4 38.9	9.519*n*	0.529	21	12
8	16 59 35	−0 25.32	− 3 52.7	6 , 6	43 9.69	26 4 58.7	9.645*n*	0.620	22	12
9	19 40 23	−0 3.18	− 4 32.9	6 , 6	46 5.86	27 14 27.8	9.325*n*	0.413	23	40
11	20 25 14	−0 1.10	− 4 33.8	6 , 6	51 5.30	29 13 49.7	9.071*n*	0.320	24	40
12	16 41 22	+0 0.62	+ 1 9.6	6 , 6	10 53 1.73	30 1 0.9	9.670*n*	0.600	25	12
16	16 45 24	+0 49.12	+ 1 7.1	6 , 6	11 1 2.36	33 26 14.3	9.677*n*	0.545	26	40
28	15 22 12	+0 18.24	− 4 0.7	8 , 8	14 42.74	40 51 38.6	9.749*n*	0.563	27	12
Feb. 4	16 40 48	−0 9.42	− 3 56.8	2 , 4	16 49.04	43 38 11.9	9.678*n*	0.198	28	12

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Instr.
Comet Taylor-Skjellerup 1920 c (*Continued*)										
1921	h m s	m s	′ ″		h m s	° ′ ″				
Feb. 13	17 0 42	+0 18.62	+ 1 58.8	8 , 8	11 15 8.32	+45 47 36.4	9.587*n*	9.688	29	40
15	22 4 41	+0 7.89	−10 49.5	8 , 8	14 14.20	46 7 6.6	9.603	9.709	30	40
17	22 6 19	−0 47.30	+ 2 54.2	8 , 8	13 19 04	46 20 50.5	9.627	9.797	31	40
Mar. 2	14 25 12	+0 11.18	+ 1 24.8	8 , 8	6 45.04	46 37 29.4	9.731*n*	0.207	32	40
8	20 38 22	−0 8.76	− 9 18.0	8 , 8	3 50.01	46 9 34.0	9.618	9.779	33	40
9	15 34 43	+1 0.85	+ 1 18.9	8 , 8	3 22.12	46 4 47.5	9.537*n*	9.537	34	40
10	20 26 5	+0 29.74	− 6 48.7	8 , 8	11 3 1.02	45 56 40.2	9.608	9.763	35	40
Comet Reid 1921 a										
Mar. 28	22 8 40	−0 11.43	+ 4 40.5	6 , 6	20 22 40.74	− 9 19 14.3	9.559*n*	0.809	36	12
29	22 30 26	+0 25.54	+ 1 55.2	6 , 6	23 15.12	− 8 26 30.1	9.515*n*	0.812	37	40
Apr. 2	22 23 32	−0 0.53	− 5 21.5	6 , 6	25 31.84	− 4 32 4.3	9.508*n*	0.796	38	40
4	21 16 32	−0 17.69	+ 0 7.2	6 , 6	26 42.51	− 2 18 47.1	0.586*n*	0.781	39	40
9	21 50 3	−0 13.83	− 1 19.4	6 , 6	29 51.05	+ 4 36 23.7	9.525*n*	0.746	40	12
17	19 41 23	−0 34.93	− 2 56.3	6 , 6	36 14.39	20 32 27.5	9.652*n*	0.700	41	12
18	22 19 33	+0 5.54	+ 0 12.2	6 , 6	37 24.19	23 24 56.2	9.443*n*	0.525	42	12
19	21 19 50	+0 2.16	− 1 27.3	6 , 6	38 29.19	26 2 9.0	9.527*n*	0.544	43	40
24	18 5 13	+0 14.08	+ 0 9.3	6 , 6	45 52.63	41 14 45.7	9.758*n*	0.690	44	12
27	17 49 1	−5 33.95	− 3 21.8	6 , 6	20 53 9.77	51 46 5.4	9.839*n*	0.649	45	12
May 3	15 39 39	+1 2.55	− 3 39.9	6 , 6	21 28 6.03	72 24 15.9	0.011*n*	0.785	46	12
4	16 2 50	−0 56.67	− 1 6.5	6 , 6	21 42 7.79	75 35 48.4	0.119*n*	0.747	47	12
5	15 32 36	+2 43.65	− 6 31.9	6 , 6	22 1 47.47	78 28 59.4	0.121*n*	0.794	48	12
7	15 34 1	−0 25.38	− 0 34.1	6 , 6	23 25 58.04	83 28 50.3	0.091*n*	0.831	49	12
8	14 17 54	+3 41 18	− 1 16.3	6 , 6	0 51 0.81	85 0 27.1	0.240	0.818	50	40
10	20 43 42	+1 52.99	− 0 53.9	6 , 6	5 4 54.88	84 12 3.7	0.015*n*	0.837	51	40
14	20 59 8	+0 23.64	− 3 59.9	6 , 6	7 10 46.71	77 2 41.4	9.476	0.879	52	40
15	14 51 11	+0 24.86	+ 5 0.5	6 , 6	16 30.88	75 51 6.6	0.239	9.258	53	40
16	15 59 49	−1 13.73	+ 3 34.5	6 , 6	25 26.69	74 7 15.9	0.198	0.321	54	12
20	14 36 39	−0 23.29	− 4 0.4	6 , 6	44 2.49	68 22 50.4	0.051	9.599	55	12
22	14 30 55	+0 16.51	+ 0 45.0	6 , 6	7 49 16.55	65 53 43.2	0.003	9.771	56	40
29	14 37 0	+0 12.24	+ 3 37.7	6 , 6	8 2 16.71	59 2 17.3	9.914	0.258	57	40
June 3	18 22 52	+0 29.22	− 1 17.5	6 , 6	4 47.27	55 0 17.9	9.702	0.867	58	40
4	15 8 35	+0 30.16	− 2 15.0	6 , 6	5 24.73	54 25 52.5	9.872	0.540	59	12
30	15 21 6	−0 9.89	+ 1 32.7	6 , 6	17 57.87	43 5 4.6	9.727	0.797	60	12
July 3	15 14 46	−0 14.87	− 1 43.1	6 , 6	8 19 7.89	42 13 45.9	9.717	0.804	61	40
Periodic Comet Winnecke 1921 b										
Apr. 17	16 18 10	+1 8.03	− 1 26.9	30 , 6	16 10 30.19	+39 13 51.9	9.688*n*	0.413	62	40
19	20 47 46	+2 26.60	+ 6 3.0	25 , 5	16 4.96	40 1 56.0	8.854	9.594	63	40
24	15 9 47	+0 24.73	+ 8 47.8	8 , 8	29 30.63	41 42 15.1	9.750*n*	0.527	64	40
27	15 44 24	+0 11.83	+ 5 24.0	6 , 6	38 39.05	42 42 6.5	9.733*n*	0.415	65	40
May 1	17 38 50	−1 23.54	+ 1 48.8	25 , 5	52 36.83	43 56 31.6	9.562*n*	9.837	66	12
3	15 56 24	+1 6.27	− 6 14.2	25 , 5	16 59 55.44	44 28 8.8	9.732*n*	0.334	67	12
4	17 4 30	−0 2.37	− 8 16.7	6 , 6	17 4 5.52	44 44 31.2	9.641*n*	0.012	68	12
5	15 0 41	−0 1.96	− 9 17.8	6 , 6	7 52.04	44 58 2.8	9.775*n*	0.498	69	12
7	15 6 52	−0 58.95	+ 2 15.3	25 , 5	16 37.01	45 25 15.0	9.775*n*	0.478	70	12

Date	G. M. T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		★	Instr.
				Periodic Comet WINNECKE 1921 *b* (*Continued*)						
1921	h m s	m s	′ ″		h m s	° ′ ″				
May 8	15 8 5	+1 13.36	+ 3 41.2	25 , 5	17 21 16.11	+45 38 9.6	9.777*n*	0.474	71	12
10	20 17 36	+1 26.65	+ 5 8.3	25 , 5	32 6.34	46 1 4.4	8.181	9.746*n*	72	12
15	15 34 44	−0 11.91	+ 2 22.1	6 , 6	59 29.31	46 28 16.7	9.775*n*	0.412	73	40
19	21 19 18	+0 6.61	− 6 42.0	6 , 6	18 28 38.42	46 15 24.4	9.100	9.698*n*	74	40
22	14 55 0	−0 40.43	+ 3 59.4	25 , 5	18 50 23.48	45 43 1.9	9.791*n*	0.593	75	12
28	16 4 40	−2 23.60	+ 4 20.5	20 , 4	19 46 34.34	42 26 52.2	9.758*n*	0.540	76	12
29	20 26 12	−0 25.20	− 3 0.7	6 , 6	19 58 30.94	41 25 5.8	9.155*n*	9.448	77	12
31	20 31 54	−1 20.26	+ 0 7.9	25 , 5	20 19 52.71	39 17 16.9	9.195*n*	9.805	78	12
June 3	19 32 45	−1 1.61	− 8 14.5	25 , 5	20 52 5.91	35 11 21.1	9.495*n*	0.260	79	12
4	17 17 36	−0 22.66	− 6 19.4	6 , 6	21 2 2.64	33 41 35.7	9.693*n*	0.579	80	12
5	20 31 40	+0 12.59	+ 2 29.3	6 , 6	21 14 24.83	31 40 45.4	9.333*n*	0.290	81	12
12	18 50 18	−0 9.29	−10 5.3	6 , 6	22 25 45.09	16 18 5.1	9.597*n*	0.682	82	40

Comparison Stars

Mean Coördinates for Beginning of Year and Reductions to Apparent Places

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
1	1 53 17.53	− 1 21 27.2	+2.39	+15.0	Alger ph. −1°, $1^h 56^m$, No. 53; −2°, $1^h 52^m$, No. 26.
2	1 56 30.00	− 1 17 38.7	2.40	15.0	Alger ph. −1°, $1^h 56^m$, No. 66; −2°, $1^h 52^m$, No. 42.
3	1 58 39.49	− 1 20 33.8	2.42	15.0	*B. D.* −1° 280 — 3 obs. *Abbadia.*
4	2 3 2.53	− 1 30 41.0	2.45	15.2	Agler ph. −1°, $2^h 4^m$, No. 62; −2°, $2^h 0^m$, No. 89.
5	2 10 29.73	− 1 34 21.0	2.50	15.2	*B. D.* −1° 306 — 4 obs. *Abbadia.*
6	2 52 36.69	− 4 2 2.7	2.93	16.5	Boss *P. G. C.* 666.
7	3 2 42.39	− 6 57 8.3	3.27	17.9	*A. G. Ott.* 706.
8	2 59 31.15	− 7 26 59.9	3.35	18.3	*A. G. Ott.* 690.
9	3 3 4.80	− 7 33 16.6	3.35	18.1	*A. G. Ott.* 708.
10	3 3 41.33	− 8 1 22.6	3.41	18.3	*A. G. Ott.* 710.
11	3 1 4.11	− 8 46 42.9	3.50	18.7	*A. G. Ott.* 698.
12	2 55 47.63	− 9 43 47.8	3.62	19.2	*A. G. Ott.* 675.
13	2 50 22.37	−11 24 53.4	3.87	19.0	*A. G. Harv.* 659.
14	2 42 55.69	−11 51 55.9	3.96	+19.1	*B. D.* −12° 522 referred to *Harv.* 633.
15	9 16 59.72	− 3 12 36.6	4.33	−21.4	*A. G. Strb.* 3623.
16	9 26 11.48	− 0 24 20.0	4.37	−22.9	Alger ph. −1°, $9^h 24^m$, No. 61; 0°, $9^h 28^m$, No. 84.
17	9 45 40.69	+ 5 49 21.5	4.44	−26.1	Anon. referred to *Kü* 4312.
18	10 24 19.79	19 20 33.9	1.33	−14.3	*A. G. Berl. A.* 4167.
19	28 34.11	20 23 41.6	1.33	−14.6	*A. G. Berl. B.* 4047.
20	33 53.66	22 45 44.8	1.35	−15.5	Paris ph. 22°, $10^h 32^m$, No. 48; 23°, $10^h 28^m$, No. 139; $10^h 36^m$, No. 106.
21	41 26.99	25 11 3.6	1.36	−16.3	Oxf. ph. 25° 38103, 38293; 26° 28950.
22	43 33.62	26 11 8.0	1.39	−16.6	Oxf. ph. 26° 29052, 27° 26719.
23	46 7.65	27 19 0.7	1.39	−16.9	Oxf. ph. 27° 26830, 28° 31730.
24	51 4.98	29 18 41.0	1.42	−17.5	Oxf. ph. 29° 30673, 30° 26053.
25	10 52 59.67	30 0 9.0	1.44	−17.7	*A. G. Lei.* 4321.

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
26	11 0 11.73	33 25 25.7	1.51	−18.5	*A. G. Lei.* 4351.
27	14 22.71	40 55 59.2	1.79	−19.9	Hels. ph. *Cliché* 471, No. 69; *Cl.* 474, No. 24.
28	16 56.54	43 42 28.4	1.97	−19.7	Hels. ph. *Cliché* 475, No. 74; *Cl.* 479, No. 12.
29	14 47.47	45 45 56.1	2.23	−18.5	Hels. ph. *Cliché* 476, No. 38.
30	14 4.03	46 18 14.4	2.28	−18.3	*Kü* 5003.
31	14 4.03	46 18 14.4	2.31	−18.1	*Kü* 5003.
32	6 31.34	46 36 20.2	2.52	−15.6	Hels. ph. *Cliché* 466, No. 71; *Cliché* 473, No. 6.
33	3 56.20	46 19 6.2	2.57	−14.2	Hels. ph. *Cliché* 466, No. 61.
34	2 28.70	46 3 42.6	2.58	−14.0	Hels. ph. *Cliché* 466, No. 55.
35	11 2 28.70	+46 3 42.6	2.58	−13.8	Hels. ph. *Cliché* 466, No. 55.
36	20 22 51.48	− 9 24 0.5	0.69	+ 5.7	*A. G. Ott.* 7256.
37	22 48.88	− 8 28 36.8	0.70	+ 5.5	*A. G. Ott.* 7255.
38	25 31.56	− 4 26 47.4	0.81	+ 4.6	*A. G. Str.* 7095.
39	26 59.37	− 2 18 58.2	0.83	+ 3.9	Alger ph. −2°, 20ʰ 24ᵐ, No. 260.
40	30 3.95	+ 4 37 41.0	0.93	+ 2.1	*B. D.* 4° 4486 — 4 obs. *Abbadia* (08.00).
41	36 48.25	20 35 25.6	1.07	− 1.8	*B. D.* 20° 4671 — 3 obs. *Abbadia* (04.99).
42	37 17.56	23 24 46.4	1.09	− 2.4	*A. G. Berl. B.* 7860.
43	38 25.95	26 3 39.3	1.08	− 3.0	Oxf. ph. 25° 70162, 26° 68223, 27° 58517.
44	45 37.38	41 14 42.1	1.17	− 5.7	*A. G. Bonn* (*Verbess.*) 14690.
45	20 58 42.56	51 49 34.1	1.16	− 6.9	*A. G. Harv.* 6869.
46	21 27 2.37	72 28 3.7	1.11	− 7.9	Grw. ph. 72° 8966.
47	43 3.45	75 37 2.7	1.01	− 7.8	Grw. ph. 75° 8317.
48	21 59 2.97	78 35 38.0	+0.85	− 7.6	Grw. astrogr. III. 5690.
49	23 26 24.07	83 29 31.2	−0.65	− 6.8	Grw. astrogr. III. 2185.
50	0 47 22.18	85 1 48.5	−2.55	− 5.1	Grw. astrogr. III. 1087.
51	5 3 4.79	84 12 56.1	−2.90	+ 1.5	Grw. astrogr. III. 1193.
52	7 10 23.19	77 6 38.3	−0.12	+ 3.0	Grw. ph. 77° 2946.
53	16 6.02	75 46 3.3	0.00	+ 2.8	Grw. astrogr. III. 7688.
54	26 40.28	74 3 38.8	+0.14	+ 2.6	Grw. ph. 74° 3031.
55	44 25.40	68 26 49.4	0.38	+ 1.4	Grw. astrogr. III. 12727.
56	7 48 59.60	65 52 57.6	0.44	+ 0.6	Grw. ph. 65° 2611.
57	8 2 3.92	58 58 40.8	0.55	− 1.2	*A. G. Hels.* 5384.
58	4 17.49	55 1 37.9	0.56	− 2.5	*A. G. Hels.* 5406.
59	4 54.01	54 28 10.3	0.56	− 2.8	*A. G. Harv.* 3055.
60	18 7.11	43 3 39.5	0.65	− 7.6	Hels. ph. *Cliché* 349, No. 69.
61	8 19 22.10	42 15 37.1	0.66	− 8.1	Boss *P. G. C.* 2220.
62	16 9 20.05	39 15 28.1	2.11	− 9.3	Sec. 10 Y (1890) No. 4086 + p. m.
63	13 36.23	39 56 1.8	2.13	− 8.8	*A. G. Bonn* (Verbess.) 10439 + *Lu* 6681.
64	28 53.68	41 33 35.1	2.19	− 7.5	*A. G. Bonn* (Verbess.) 10585.
65	38 24.99	42 36 49.3	2.23	− 6.8	*A. G. Bonn* (Verbess.) 10673.
66	51 11.01	43 54 49.2	2.28	− 6.0	*A. G. Bonn* (Verbess.) 10804.
67	16 58 46.86	44 34 28.6	2.31	− 5.6	*Kü* 7550.
68	17 4 5.57	44 52 53.0	2.32	− 5.2	*B. D.* 44° 2654 — *Bonn V.*
69	7 51.66	45 7 25.6	2.34	− 5.0	*A. G. Bonn* (Verbess.) 10995.
70	17 33.60	45 23 4.0	2.36	− 4.3	*A. G. Bonn* (Verbess.) 11105.
71	20 0.37	45 34 32.5	2.38	− 4.1	*Kü* 7713.
72	30 37.29	45 55 59.7	2.40	− 3.6	*A. G. Bonn* (Verbess.) 11258.
73	17 59 38.77	46 25 57.3	2.45	− 2.7	*A. G. Bonn* (Verbess.) 11637.
74	18 28 29.32	46 22 8.2	2.49	− 1.8	*A. G. Bonn* (Verbess.) 12055.

No.	α	δ	Red. α	Red. δ	Authority
	h m s	° ′ ″	s	″	
75	18 51 1.39	45 39 3.5	2.52	− 1.0	*Kü* 8380.
76	19 48 55.43	42 22 31.6	2.51	+ 0.1	*A. G. Bonn* (Verbess.) 13473.
77	19 58 53.62	41 28 6.0	2.52	+ 0.5	*A. G. Bonn* (Verbess.) 13671.
78	20 21 10.46	39 17 8.0	2.51	+ 1.0	*A. G. Lu* 9344.
79	20 53 5.04	35 19 33.6	2.48	+ 2.0	*Kü* 9271.
80	21 2 22.84	33 47 52.6	2.46	+ 2.5	*A. G. Lei* 8703.
81	21 14 9.80	31 38 13.0	2.44	+ 3.1	*A. G. Lei* 8838.
82	22 25 52.13	16 28 2.8	2.25	+ 7.6	*A. G. Berl. A* 9196.

REMARKS

☄ 1920 *a*

July 20 Nebulosity about 2′ in length with eccentric condensation towards the south. Total brightness $9^{M}.0$.

July 21 Through clouds.

July 27 Stellar nucleus of about 14^{M}. Short tail 1½′ in length in position angle 10°. Total brightness $10^{M}.0$.

Aug. 21 Short diffuse tail in first quadrant. Settings difficult on diffuse nebulosity. Total brightness 10^{M}.

Sept. 7 Difficult on account of moonlight. Eccentric stellar condensation about 14^{M}. Nebulosity extends over 1′ in position angle 22°. The position is possibly ½R = 4″.8 north of the one given, because of an error of one revolution in the reading of one of the two series in declination.

Sept. 11 Nucleus about $14^{M}.5$. Nebulosity very faint.

Sept. 14 Faint nucleus about $14^{M}.5$. Total brightness $13^{M}.5$.

Oct. 7 Total brightness 14^{M}.

Nov. 13 Visible in 40 inch as a faint nebulosity of about 1½′ in diameter without nucleus. No suitable comparison stars.

☄ 1920 *c*

Dec. 17 Round nebulosity of 1½′ in diameter. Total brightness 10^{M}. Diffuse nucleus 11^{M}.

Jan. 5 The nebulosity is more extended in position angle 270°. The nucleus is not sharp and well elongated in a direction 90–270°. Total brightness $10^{M}.5$.

Jan. 11 Nucleus elongated towards 275°; its brightness only 13^{M}. Total brightness 11^{M}.

Jan. 28 Total brightness $12^{M}.5$. Central condensation $13^{M}.5$.

Feb. 13 Round nebulosity 1′ in diameter, 13^{M} total brightness. Central condensation $14^{M}.5$.

Feb. 15 About 14 sec. prec. and 3′ north of the comet there is an anonymous nebula presenting a striking resemblance to the comet: round, faint central condensation, diameter 1½′ but 1^{M} brighter than the comet. For 1900.0 the position of the nebula is:

$11^{h}\ 12^{m}\ 47^{s}.72 \quad 46°\ 4'\ 0''.7$

Feb. 17 Diameter 50″. Total brightness 14^{M}. Central condensation only 15^{M}.

Mar. 8–9–10. Object extremely difficult. Settings very uncertain.

☄ 1921 *a*

Apr. 2 Nebulosity extends 5′ in position angle 230°. Total brightness $0^M.2$ below the comparison star or $8^M.2$.

Apr. 4 Nebulosity extends 6′ in position angle 230°. Magnitude:
B. D. −2° 5279 ($8^M.0$) −2 − ☄ − 2 − *B. D.* −2° 5281 ($7^M.8$) hence $7^M.9$.

Apr. 9 The tail short points towards 210°.
B. D. 3° 4356 ($7^M.2$) − 1 − ☄ − 2 −*B. D.* 4° 4484 ($7^M.7$) hence $7^M.3$.

Apr. 17 Stellar nucleus $9^M.0$. Total brightness $6^M.7$.

Apr. 18 The head is 5′ in diameter; a short tail about 10′ in 215°. Stellar nucleus $9^M.0$. Total brightness (finder):
B. D. 23° 4085 ($6^M.8$) − 2 − ☄ − 1 − *B. D.* 23° 4107 ($7^M.3$) hence $7^M.2$.

Apr. 27 Total brightness (finder):
P. D. 12009 ($6^M.07$) − 3 − ☄ − 3 − *P. D.* 12004 ($6^M.76$) hence $6^M.4$.

May 3 Total brightness (naked eye):
P. D. 12658 ($5^M.29$) − 2 − ☄ − 1 − *P. D.* 12167 ($6^M.16$) hence $5^M.8$.

May 4 Stellar nucleus 8^M. Nebulosity, 4′ in diameter, extends 12′ in 220° and another branch 5′ in 275°. Total brightness (binocular):
P. D. 12844 ($5^M.34$) − 2 − ☄ − 1 − *P. D.* 12658 ($5^M.29$) hence $5^M.3$.

May 7 Total brightness (finder):
B. D. 86° 344 ($6^M.0$) − 4 − ☄ − 2 − *B. D.* 83° 20 ($7^M.0$) hence $6^M.7$.

June 4 Total brightness $0^M.6$ fainter than comparison star, hence $8^M.6$.

June 30 Faint nebulosity near horizon.

July 3 Difficult at low altitude.

☄ 1921 *b*

Apr. 24 Total brightness $11^M.5$ — Faint stellar nucleus.

May 4 Total brightness $10^M.8$. Nebulosity about 2′ in diameter with central condensation and slightly elongated towards 250°.

May 8 Total brightness $11^M.0$. Nucleus 12^M.

May 28 Total brightness $10^M.0$. Small nucleus somewhat eccentrical so that nebulosity extends mostly towards 50°.

May 29 The nebulosity is about 10′ in diameter and the central condensation is faint.

June 4 Total brightness $9^M.5$.

June 12 Total brightness estimated in finder:
B. D. 16° 4746 ($7^M.5$) − 5 − ☄ − 5 − *B. D.* 16° 4748 ($8^M.6$) hence $8^M.0$.
Nucleus only 12^M. Nebulosity extends 3′ in direction 36°.

Williams Bay, Wis.,
July, 1921.

ELEMENTS OF COMET *a* 1921, (REID),

By R. A. ROSSITER,

Computed at the Detroit Observatory from observations on March 14, March 28, and April 10

Time of perihelion passage	(T)	1921 May 9.9734 G. M. T.	
Longitude of perihelion	(π)	332° 51′ 25″	
Longitude of ascending node	(Ω)	268 20 20	1921.0
Inclination	(i)	132 8 50	
Log perihelion distance	($\log q$)	0.003646	

Motion retrograde

NOTE ON AN ANNUAL TERM IN THE RIGHT ASCENSIONS,

[Third Paper.]

By M. L. ZIMMER.

In two recent numbers of the *Astronomical Journal* it was shown that clock corrections determined at or near sunset were uniformly larger by $^s.04$ or $^s.05$ than the corresponding ones determined at or near sunrise. This was later fully confirmed by TUCKER and others. (1) (2) (3).

From these results I think we are all agreed that we are dealing with a very real and definite phenomenon and that the further publication of data to establish its reality would be merely repetitious and therefore unnecessary. It only remains, then, to determine its nature and if possible to discover its cause.

In order to determine the form of the curve described during the year the 6 and 18 hour groups were observed on every favorable occasion during 1920. The results of these observations have shown that the curve is a continuous one, with no steep gradients on either side of sunrise or sunset such as we should expect if the phenomenon were due to a lateral refraction effect. The mean results are represented by the formula $+^s.02 \sin (\alpha - \odot)$ = (correction to observed transits) practically without residual error. These results receive considerable support both from the Washington-Paris Longitude determinations by radio signals and from the Cape Fundamental observations for 1900. From the Cape Catalogue, however, only those observations made during 1910 are adequate for determining this term since only in that year were the observations made in such a way that the day minus night effect could be separated from that of morning minus evening. A least square solution of the results of that year gave precisely the same formula as that found from mine of 1920. Solutions for the other years were indeterminate.

The fact that certain stars of the group for three consecutive years have consistently given Δs two or three times as large as others and the fact that they all consistently follow the above curve points strongly to something inherent in the stars themselves as the cause rather than to a terrestial one. If due to a terrestial cause, such as variation in the personal equation of the observer from evening to morning, diurnal variation of the clock rate, inequalities in the revolution of the *Earth* on its axis, or lateral refraction, etc., we should expect the Δs to be the same for all stars.

Both the Washington and Greenwich observations of the *Moon* contain a term of similar character, *i. e.:* corrections to its ephemeris are always found to be larger from the evening observations than from the morning ones. If any part of this is due to variations in the clock corrections such as those pointed out it shows that the cause producing such variations in the clock corrections is a stellar one, since if it were a terrestial one it would affect the observations of the *Moon* exactly the same as those of the stars and there would be no such deviations in the *Moon's* place. With the aid of BROWN's new tables, the *Moon* might be made to yield results comparable to those of the planets for testing the phenomenon.

In order to determine whether the cause is a stellar or terrestial one we have had recourse to observations of the two outer planets. Theoretically observations of both the *Moon* and outer planets made at or near 6 o'clock in the evening and morning furnish a test. These planets move so slowly that for several years they may be compared directly with a group of stars having the same R. A. as the planet. Now if the phenomenon which causes the clock corrections to be $^s.04$ or $^s.05$ larger in the evening than in the morning is a true stellar one then we should expect the corrections to the planet's ephemeris to be larger in the evening than in the morning; but on the other hand if due to any terrestial cause there should be no such deviations. Observations of *Neptune* made in December and April by TRETTER and of *Uranus* made in November and June by GUÉRIN do show such deviations and by just about $^s.04$. Furthermore the corrections found from midnight observations fall almost exactly half way between the evening and the morning ones. Of course one year's observations are too few to establish proof but coupled with the other accumulated evidence make a strong case for a stellar cause, and should further observations confirm the above results it will furnish the complete solution of the problem; but on the other hand if further observations establish the fact that the true cause is a terrestial one it will, in all probability, require an extensive investigation to arrive at a complete solution, and will probably require the coöperation of observatories 180° distant as well as the transmission of time by radio signals.

The main object of this note is to call the attention

1. *Lick Observatory Bulletin* No. 323 and 330.
2. Washington-Paris Longitude determination by Radio Signals *A. J.* Vol. XXIX No. 1-2.
3. Report of the Director of the Department of Meridian Astrometry Carnegie Year Book for 1920.

of astronomers to the desirability of making observations of the outer planets and the *Moon* about 6 hours either side of the *Sun* in order to determine how much, if any, of the variation in clock corrections between evening and morning is due to stellar causes, since the correct solution of this problem is necessary for all branches of astronomy which depend on the determination of the exact time.

Observatorio Nacional Argentino
Córdoba, June, 1921

ECLIPSES OF *JUPITER'S* SATELLITES IN 1921,

OBSERVED AT THE YERKES OBSERVATORY,

By GEORGE VAN BIESBROECK.

The observations, made with the 40-inch or the 12-inch refractor, consisted mainly in recording the time of the first or last speck of light. In addition some estimations of the magnitude at various moments during the phenomena were noted. G. M. T. has been used throughout. The conditions of observation are indicated on a scale from 1 (very poor) to 5 (perfect). O — C indicates the deviations from the ephemerides computed by the *Bureau des longitudes* from *Sampson's* tables.

(1) Jan. 9 I. Disapp.

$21^h\ 21^m\ 59^s$ 10^M
22 23 11
22 45 13
21 22 54 ∞

40 inch. Seeing 3.
$O - C = +1^m.2$

(2) Jan. 11 I. Disapp.

$18^h\ 29^m\ 7^s$ 10^M
29 21 11
29 40 12
30 2 ∞

12 inch. Seeing 3.
$O - C = +1^m.1$

(3) Feb. 24 I. Disapp.

$21^h\ 38^m\ 42^s$ 10^M
38 56 11
39 4 12
39 24 ∞

40 inch. Seeing 3.
$O - C = +1^m.2$

(4) April 3 II. Reapp.

$15^h\ 8^m\ 26^s$ ∞^M
8 46 12
9 2 10

40 inch. Seeing 2.
$O - C = -2^m.3$

(5) May 8 I. Reapp.

$13^h\ 25^m\ 32^s$

40 inch. Seeing 3. Sky not quite dark yet.
$O - C = -2^m.5$

(6) May 8 III. Reapp.

$13^h\ 29^m\ 54^s$

40 inch. Seeing 3. Perhaps a couple of seconds earlier. Taken by surprise through deviation from prediction. $O - C = 5^m.6$

(7) May 15 III. Disapp.

$14^h\ 28^m\ 7^s$ 10^M
29 1 11
29 40 12
30 29 ∞

40 inch. Seeing 2.
$O - C = +5^m.2$

(8) May 15 I. Reapp.

$15^h\ 20^m\ 38^s$

40 inch. Seeing 2.
$O - C = -2^m.5$

(9) May 22 I. Reapp.

$17^h\ 15^m\ 58^s$

40 inch. Seeing 1.
$O - C = -2^m.4$

(10) July 8 II. Reapp.

$13^h\ 58^m\ 38^s$

12 inch. Seeing 2. Sky not yet dark. $O - C = -2^m.5$

Williams Bay, Wis.,
July, 1921.

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